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Development and Application of an Automated Data Analyzer

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Unit-Collective Training Research Unit

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In order to seek and test determinants of unit effectiveness, the ADA was developed based on the idea that search and analysis of large amounts of data can be automated if variables can be converted into a standard form. In addition, the methodology permits an analyst to identify, in a first iteration, large sets of variables and associated parameters he/she thinks may be relevant to an issue, and assist in their refinement, combination, and elimination in later iterations. The ADA does this by providing a concise visual presentation of the relationships among a large number of variables. This facilitates identification of variables and combinations of variables, in complex data sets, that are related to mission outcomes and to each other.

Project results show that the ADA analysis can be used to extract mission effectiveness information from the ARI National Training Center (NTC) data base for analyst review and automated data analysis. The method allows considerable flexibility allowing the analyst to adjust, modify, and create new analyses with some ease and flexibility. Use of analysis specification files allows automatic documentation and the repeated use of analyses. Complex analyses can be gradually built to assess company/team and task force (TF) performance.

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AUTOMATED DATA ANALYZER FOR NTC DATA

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EXECUTIVE SUMMARY

Requirement:

In order to seek and test determinants of unit effectiveness, the Automated Data Analyzer (ADA) was developed based on the idea that search and analysis of large amounts of data can be automated if variables can be converted into a standard form. In addition, the methodology permits the analyst to identify, in a first iteration, large sets of variables and associated parameters he/she thinks may be relevant to an issue, and assist in their refinement, combination, and elimination in later iterations. The ADA does this by providing a concise visual presentation of the relationships among a large number of variables. This facilitates identification of variables and combinations of variables, in complex data sets, that are related to mission outcomes and to each other. It also helps to identify the variable parameters that are meaningful for analysis.

Procedure:

In order to seek and test determinants of unit effectiveness, the ADA was developed based on the idea that search and analysis of large amounts of data can be automated if variables can be converted into a standard form. In addition, the methodology permits the analyst to identify, in a first iteration, large sets of variables and associated parameters he/she thinks may be relevant to an issue, and assist in their refinement, combination, and elimination in later iterations. The ADA does this by providing a concise, visual presentation of the relationships among a large number of variables. This facilitates identification of variables and combinations of variables, in complex data sets, that are related to mission outcomes and to each other. It also helps to identify the variable parameters that are meaningful for analysis.

To accomplish this search and analysis in a standard way, the analyst specifies the real world variables for ADA to analyze. The analyst also specifies how ADA is to convert the variables into the standard form. ADA then accepts data for those variables from data files and converts them into a standard binary form so that standardized analysis tools can be applied to the data. An independent rating of unit effectiveness on the mission is used as the dependent variable to guide the search and analysis.

The ADA software consists of two parts. One part uses "Boolean Questions" (BQ), i.e., those with binary, yes or no answers which implement the parameters such as the numerical ranges to transform the mission data into a set of answers to the Boolean Questions. The second part analyzes the answers to predict mission effectiveness. Overall, the analysis is iterative requiring the analyst to select an initial set of BQs and conduct the analyses, followed by the analyst's refinement of the BQs. This is followed iteratively by another analysis, and so forth, each analysis improving the correlation between the predicted and actual mission effectiveness ratings or prediction of another variable.

Boolean Questions (BQ) consist of the BQ variable, such as the distance of the BLUE FORCE from the objective, and parameters, such as more than 8000 meters, to ask a specific question about the mission. Answers to the boolean questions produce time varying yes/no sequences, known as "boolean time sequences" (BTS), which document the changing answers to the questions as a function of mission time. For instance, some questions might implement the parameters illustrated above by asking about the range from a Company Team (co/t) to the objective.

Three types of analyses are applied to the BTS:

1. Time line analysis,
2. Relative analysis, and
3. Transition analysis.

Each analysis examines the BTS to identify data patterns whose frequency of occurrences are associated with the level of mission effectiveness. Each different analysis looks for a different type of discriminent pattern. Pattern measures from each of the different analyses found to be associated with unit effectiveness are combined to form an overall predictor of unit effectiveness.

Findings:

Project results show that the ADA analysis can be used to extract mission effectiveness information from the ARI National Training Center (NTC) data base for analyst review and automated data analysis. The method allows considerable flexibility in combining co/t, BQ, and Boolean question parameters. The analyst can adjust, modify, and create new BQ with some ease and flexibility. BQs adjustments are made by modifying the BQ parameters. Existing BQs are modified and new BQs created by defining company/teams (co/ts), selecting different BQ variables, and by modifying the BQ parameters. Use of analysis data files allows automatic documentation of analyses, and the repeated use of analyses. Simple and complex analyses can be gradually built to assess co/t and Task Force (TF) performance. Some complex analyses can be built by creating more complex co/ts. For instance, an existing co/t can be converted into a new co/t that includes engineers simply by adding the engineer's vehicles to the list of co/t members. Also, one or more scout "co/ts" can be created to include their function into the analysis. If a new type of BQ is needed, additional programming will be required.

Utilization of Findings:

Analysis of ARI NTC data documented in this report show how to use the ADA system to form specific hypothesis, and then analyze missions to test the hypothesis. Mission decomposition also permits direct comparison of the dynamics of selected missions. Two missions are compared indicating the superiority of one over the other.

AUTOMATED DATA ANALYZER
FOR NTC DATA

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INTRODUCTION

The Automated Data Analyzer (ADA) provides an automated search and analysis of data to seek and test discriminants of unit effectiveness. To accomplish that search and analysis in a standard way, the analyst specifies the real world variables for ADA to analyze. The analyst also specifies how ADA is to convert the variables into the standard form. ADA then accepts data for those variables from data files and converts them into a standard binary form so that standardized analysis tools can be applied to the data. An independent rating of unit effectiveness on the mission is used as the dependent variable to guide the search and analysis. In addition to this report, ADA software was delivered to ARI which provides the data conversion and analysis.

ANALYSIS NEEDS

The military analyst needs two types of tools to assess broad implications of military doctrine, training, and weapons systems, and in a more narrow sense, to assess effectiveness of particular training exercises. First a reliable, comprehensive, and generally accepted measure must be available to rate unit effectiveness (an MOE) in accomplishing a mission. That measure must provide an effectiveness assessment even though it can be achieved in a variety of ways. A previous project focused on development of MOEs (Connelly, Myers 1993).

In addition, and equally important, is a data analysis method that can assess the linkage of mission processes to the unit effectiveness. The analysis method must allow for or account for the varying conditions of a mission and further must permit formation of complex analysis which extract relevant information from multiple variables while ignoring irrelevant data from the data base. This project focuses on the latter need, the analysis methodology. In particular, the analysis method employed here provides a flexible analysis permitting:

1. Focus on selected portions of the mission space through the use of mission state variables, (For example: the analyst may want to know if a unit is firing inside or outside effective range of weapons – if firing outside that range, it may not matter how far outside),

2. Use of powerful prestructured analysis tools,

3. Characterization of mission processes and examination of the relationship between combined mission processes and mission effectiveness, and

4. Building analysis variables which can be made as simple or as complex as necessary as knowledge of the importance of mission processes to mission effectiveness is obtained.

This report documents research titled Development and Application of An Automated Data Analyzer performed on ARI Contract No. MDA903-92-C-0085. Work on the project started in May 1992 and was completed in September 1993.

CONCEPTS

In order to seek and test determinants of unit effectiveness, the ADA was developed based on the idea that search and analysis of large amounts of data can be automated if variables can be converted into a standard form. In addition, the methodology permits the analyst to identify, in a first iteration, large sets of variables and associated parameters he/she thinks may be relevant to an issue, and assist in their refinement, combination, and elimination in later iterations. The ADA does this by providing a concise visual presentation of the relationships among a large number of variables. This facilitates identification of variables and combinations of variables, in complex data sets, that are related to mission outcomes and to each other. It also helps to identify the variable parameters that are meaningful for analysis.

The methodology requires the analyst to identify variables and their associated parameters that are hypothesized to be relevant to an issue. For example, the variable may be distance of the BLUE FORCE from the objective and the parameters: more than 8000 meters, 8000 to 4001 meters, 4000 to 3001 meters, 3000 to 2001 meters, 2000 to 1001 meters, 1000 to 500 meters, and less than 500 meters. This information is then input into the software.

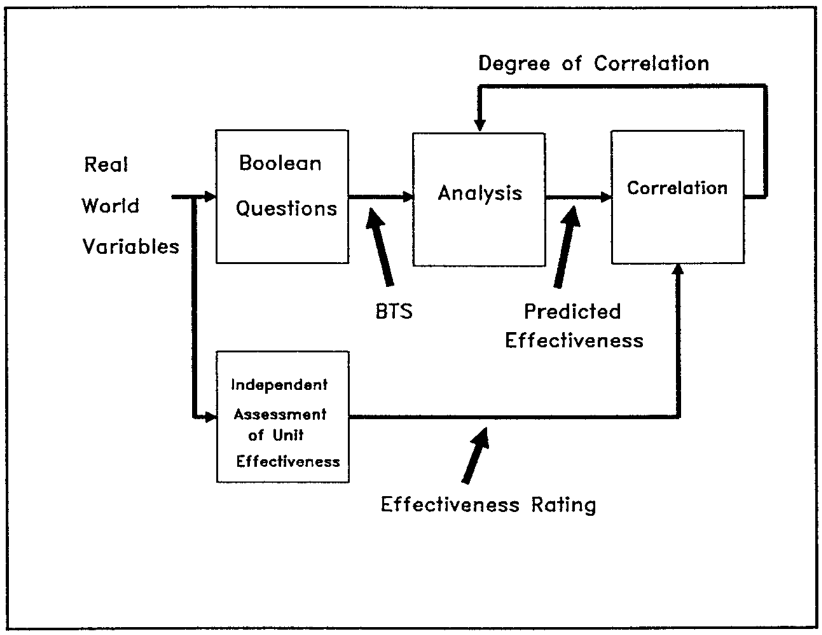

Figure 1 Automated Data Analyzer

The ADA software consists of two parts, as shown in Figure 1. One part uses "Boolean Questions" i.e., those with binary, yes or no answers which implement the parameters such as the numerical ranges cited above, to transform the mission data into a set of answers to the Boolean Questions. The second part analyzes the answers to predict mission effectiveness. Overall, the analysis is iterative requiring the analyst to select an initial set of BQs and conduct the analyses, followed by the analyst's refinement of the BQs. This is followed iteratively by another analysis, and so forth, each analysis improving the correlation between the predicted and actual mission effectiveness ratings or prediction of another variable. At each iteration the analyst develops a better understanding of the relationships between mission process and mission effectiveness.

Boolean Questions

Boolean Questions (BQ) consist of the BQ variable (BQV), such as the distance of the BLUE FORCE from the objective, and parameters, such as more than 8000 meters, to ask a specific question about the mission.

Answers to the boolean questions produce time varying yes/no sequences, known as "boolean time sequences" (BTS), which document the changing answers to the questions as a function of mission time. For instance, some questions might implement the parameters illustrated above by asking about the range from a co/t to the objective.

The Boolean Questions could be:
Q1: Is the co/t greater than 8000 meters from the objective?

Q2. Is the co/t less than 8000 meters and greater than 4000 meters from the objective?

Q3. Is the co/t less than 4000 meters and greater than 3000 meters from the objective?

And so forth with additional Boolean Questions. As the co/t approaches the enemy, the BTS corresponding to those questions would be as shown in Figure 2.

Sampling Interval (Time)

	1	2	3	4	5	6	7	. . .
BTS 1	T	T	T	F	F	F	F	. . .
BTS 2	F	F	F	T	T	F	F	. . .
BTS 3	F	F	F	F	F	T	T	. . .

"T" Indicates a true answer to the Boolean Question

"F" Indicates a false answer to the Boolean Question

Figure 2 Boolean Time Sequences (BTS)

Two types of BQ are asked. One type extracts mission state information which lets the analyst and other BQs know the mission state[1], the dynamic conditions of the mission that are believed to be important to mission effectiveness e.g., distance of a co\team from the objective, as illustrated above. The

[1] Mission State is defined by a set of mission state variables which taken as a whole indicate the mission situation. Mission variables can include variables describing friendly and enemy force makeups, conditions, and locations as well as terrain and environmental conditions. State variables are selected to identify mission dynamics. Examples of mission state variables include Company/team locations and strength, location of scouts, the status/currency of mission plans, etc. For instance, typically used state variables are "is the enemy in range of friendly direct fire weapons?" and "Are friendly forces in range of the enemy direct fire weapons?".

analyst must select a concise set of mission state variables that decompose the mission into components each requiring different activities to achieve its own objective.

A second type of BQ extracts information believed to be relevant to assessing mission effectiveness. The second type often includes state variables to permit measurement of specific activities during specific mission states, e.g., "Is the company/team (co/t) less than 4000 meters and greater than 3000 meters from the objective? AND Is the co/t using its direct fire weapons to engage the enemy?"

The second type of BQs can be relative questions. For example, state questions can identify the location of friendly weapon systems and units, where a unit was when it was hit, and the attacking OPFOR weapon systems and their locations. Relative questions can be built from the data base itself. A relative question might ask if a tank dispersion (distance across the platoon) is equal to the mean dispersion of ten selected superior NTC missions, plus or minus one standard deviation. Another question might be the same except for the tolerance of plus or minus 1.5 standard deviations, and so forth.

Other questions might define concepts useful for investigations - such as definitions of subordinate unit performance, procedures used by the unit, goals and plans established for the unit, and critical salient events such as fratricide. Boolean questions used in particular analyses are identified in the following paragraphs and defined in Appendix A. Appendix A is organized as a handbook providing technical data regarding the concepts only introduced here.

The set of potential boolean questions is often large, consisting of several hundred or more.A number of these BQs are often used in a fine grain and comprehensive initial mission analyses, indicating, for instance, a team's presence in each 500 meter interval. This aids in understanding the entire mission. Then, for subsequent analyses only the ranges to the objective found to be relevant to effectiveness assessment are used.

The transformation to BQs is not just to convert each variable individually into binary form, but rather, is to extract useful data by asking sets of relevant questions. Some of these questions may be simple, involving just one variable -- often simple concepts serve well. While in other instances complex questions involving many variables may be needed.

Analysis of BTS

Three types of analyses are applied to the BTS:

1. Time line analysis,
2. Relative analysis, and
3. Transition analysis.

Each analysis examines the BTS to identify data patterns whose frequency of occurrences are associated with the level of effectiveness. Each different analysis looks for a different type of discriminent pattern. Pattern measures from each of the different analysis found to be associated with unit effectiveness are combined to form an overall predictor of unit effectiveness.

Each type of analysis seeks to find specific types of BTS pattern differences associated with varying mission effectiveness. In each analysis, ADA measures patterns with a set of coefficients. Differences in coefficient values for different sets of mission data are the process-based indicators of mission effectiveness sought to reveal how effective missions are actually accomplished. The following sections describe the methods used to develop these coefficients.

<u>Time line analysis.</u> The time line analysis searches a BTS to find patterns whose frequencies of occurrence are related to the unit effectiveness ratings. To accomplish that goal, the time line analysis characterizes an individual BTS, or a segment of a BTS, such as one of those in Table 1, by comparing it to a set of fixed reference sequences, as shown in Table 2. This produces a coefficient measuring the degree of similarity of the BTS with each member of the reference set. This approach uses a generalized reference set which can characterize any sequence under study, i.e., the BTS does not have to exactly match any of the reference set - the coefficients uniquely characterize the BTS. In fact, the coefficients provide sufficient information to reconstruct the original BTS, demonstrating that no information is lost by the characterization. Coefficient patterns for effective missions are compared to those of less effective missions. Where differences are found, the patterns are candidates for the set of critical functions whose performance is critical to achieving highly effective missions.

To illustrate this analysis and put it in a familiar context, consider a unit communication channel analysis. The analyst would like to determine if the level of mission effectiveness is consistently associated with the frequency of certain communication use patterns. Suppose that the use of a communication net were recorded during a mission and that information is coded in a computer data file. The analyst would direct the ADA processor to read the data file and test the communication use with a BQ that asks only if the net was used during a time interval, i.e., if the net was used during the time interval the BQ answer would be TRUE, otherwise the answer would be FALSE. The mission can be divided into intervals corresponding to sequential portions of the mission such as the 8 intervals shown in Table 1. In that table, BTS 1 and BTS 2 represent, hypothetically, the communication use patterns typical for more effective and less effective missions, respectively. The Time Line Analysis attempts to characterize each of these patterns to build a discriminate of mission effectiveness based on communication net use.

Table 1 Two Boolean Time Sequences

Boolean Time Series	Time Intervals							
	1	2	3	4	5	6	7	8
BTS 1	T	T	T	T	F	F	F	T
BTS 2	T	T	F	F	T	T	F	T

This characterization process is described here using the 8 intervals shown in Table 1 as an example. The actual analysis can use a greater or lesser number of intervals depending on the analysis needs. Characterization compares each BTS to a set of reference patterns in a correlation-like analysis. Reference patterns shown in Table 2 are compared to each BTS one interval at a time, producing the matrices shown in Tables 3 and 4 for BTS 1 and 2, respectively. Consider comparing BTS 1 to reference pattern R1. The value of BTS 1 for time interval 1 is "T" which is the same as the T in R1 for the 1st time interval. Thus an "S" (for same) is entered into the similarity matrix for BTS 1 as

Table 2 Reference Sequences

Reference	Time Intervals							
	1	2	3	4	5	6	7	8
R1	T	T	T	T	T	T	T	T
R2	T	F	T	F	T	F	T	F
R3	T	T	F	F	T	T	F	F
R4	T	F	F	T	T	F	F	T
R5	T	T	T	T	F	F	F	F
R6	T	F	T	F	F	T	F	T
R7	T	T	F	F	F	T	F	T
R8	T	F	F	T	F	T	T	F

shown in Table 3. Next, the value of BTS 1 for time interval 2 is compared to that of reference R1 for time interval 2, resulting in an "S" in the next cell of that row in the matrix. Comparison of BTS 1 and R1 results in the sequence "S S S S D D D S", as shown in the matrix. Continuing with the analysis, BTS 1 is compared with each of the other reference patterns, completing that portion of the matrix. To complete the matrix, the similarity coefficients are calculated by counting the number of Ss, subtracting the number of Ds for each row and then dividing by the number of intervals in the row. In row 1, indicating the similarity with R1, there are 5 Ss and 3 Ds, producing a coefficient value of .25.

Table 4 gives the similarity matrix for BTS 2. Comparison of the coefficients for BTS 1 and 2, shown in Tables 3 and 4, reveals that coefficients for reference patterns R3, R5, and R7 discriminate BTS 1 from BTS 2. Thus, if BTS 1 and BTS 2 are associated with different levels of mission effectiveness, then these three coefficients are candidate indicators of mission effectiveness. They would be used with additional indicators from the Relative and Transition analyses to build a comprehensive process based predictor of mission effectiveness.

The Time Line Analysis is similar to a correlation analysis. If the BTS pattern is exactly equal to a reference pattern, the resulting coefficient equals 1.0. If the BTS pattern is exactly the opposite of the reference pattern, the coefficient is -1.0. If the BTS has no similarity to a reference pattern, which occurs when half the intervals are similar and half different, the coefficient is 0.0.

Reference patterns are generated to provide a set of independent patterns, meaning that comparison of any reference pattern with any other reference pattern always results in a coefficient with a zero value. This means that each reference pattern is measuring, via the comparison, a different property of the BTS. This provides an efficient analysis system.

The reference set of fixed pattern sequences have been used for many years in communication engineering and are well known in the literature as Walsh functions (Campanella, 1970), Sequency (Harmuth, 1962), and Hadamard Transforms (Whelchel & Guinn 1968). They have been used to characterize patterns in many different applications. NASA, for instance, uses a version of it to characterize pictures taken in deep space. Only the characterization coefficients substantially different from zero are transmitted back to earth where the picture is reconstructed. This not only saves power but also insures high picture quality. The important feature of this time line analysis method is that it has a high probability of distinguishing important features of a sequence without having to know what those important features are beforehand.

A potential application of the time line analysis tool is the characterization of communication- use patterns during various mission phases. Likely, these pattern analyses would be combined with other analyses such as those indicating the relative location of forces and phases of the mission, i.e., certain communication patterns may help discriminate (in part) more effective units from less effective units at specific mission phases.

Table 3 Similarity of BTS 1 & Reference BTSs

Reference	Sequence ———>								Coefficient
R1	S	S	S	S	D	D	D	S	.25
R2	S	D	S	D	D	S	D	D	-.25
R3	S	S	D	D	D	D	S	D	-.25
R4	S	D	D	S	D	S	S	S	.25
R5	S	S	S	S	S	S	S	D	.75
R6	S	D	S	D	S	D	S	S	.25
R7	S	S	D	D	S	D	S	S	.25
R8	S	D	D	S	S	D	D	D	-.25

S – BTS and Reference samples are the same.
D – BTS and Reference samples are different.
Coefficient = # same - # different

Table 4 Similarity of BTS 2 & Reference BTSs

Reference	Sequence ———>								Coefficient
R1	S	S	D	D	S	S	D	S	.25
R2	S	D	D	S	S	D	D	D	-.25
R3	S	S	S	S	S	S	S	D	.75
R4	S	D	S	D	S	D	S	S	.25
R5	S	S	D	D	D	D	S	D	-.25
R6	S	D	D	S	D	S	S	S	.25
R7	S	S	S	S	D	S	D	S	.50
R8	S	D	S	D	D	S	D	D	-.25

S – BTS and Reference samples are the same.
D – BTS and Reference samples are different.

Relative analysis. Relative Analysis is designed to extract meaningful relationships among the boolean variables and determine if measures of those relationships are related to mission effectiveness. Figure 3 is a diagram of the Relative Analysis Process. The analyst selects independent variables to be used as inputs to the process. The analyst also selects another variable to be the dependent variable predicted. Finally, the analyst organizes mission performance data files to group together missions with similar effectiveness ratings.
The data files are read and a logic developed for each category of mission effectiveness. Logic is defined by its coefficients. Thus, comparison of the logic coefficients for each mission effectiveness category identifies coefficient differences associated with mission effectiveness. The coefficients that are different as mission effectiveness changes are used as effectiveness prediction variables.

When the dependent variable is a BQ indicating a level of mission effectiveness, i.e., the logic is used to predict a level of mission effectiveness, the Relative Analysis builds a new variable that may be more relevant to mission effectiveness than its independent variables taken individually.

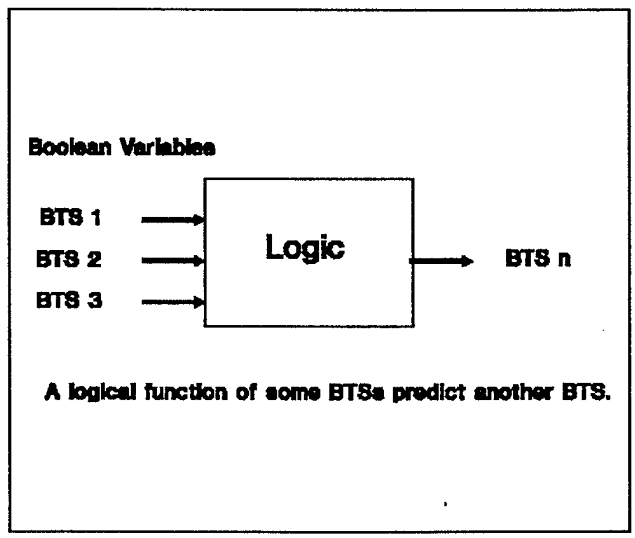

Figure 3 Relative Analysis

For instance, three independent variables might be used to predict a level of mission effectiveness, resulting in a new variable labeled "alpha": "the attack company/team direct fire weapons are in range of the objective" AND "the company/team is moving toward the objective with a specified velocity range (i.e., maximum and minimum velocities are specified)" AND "the company/team providing overwatch is firing effective suppression fire on the objective". Alpha is a new variable which may be more predictive of mission effectiveness than any of the independent variables taken individually. Alpha could be built by the analyst's guided search of the data, using the Relative Analysis to find such logical functions. These logical functions, found using the Relative Analysis, can be more complicated than just logical AND combinations of variables. Any logical function is possible.

Note that the constructed variable "alpha" isolates a portion of the mission state space eliminating all other portions of the mission. Thus, it could be used as new state variable to focus analysis of yet another variable in just that portion of the mission. Thus, ALPHA being TRUE AND and another variable being TRUE would focus on the other variable during those mission intervals only when ALPHA is TRUE and would ignore all other mission intervals. There may be alternative ways of achieving mission effectiveness, i.e., various effective missions may demonstrate different techniques for achieving effectiveness and each of those is different from those techniques demonstrated in less effective missions. The OR logic function provides a direct and visible means for including these alternatives in the logic. For instance, if some effective missions are associated with the "alpha" logic and another set of effective missions associated with another logic "beta" then the overall logic "alpha OR beta" is a new constructed variable that combines both ways of achieving effectiveness.

<u>Method</u>

Any logical function of N variables can be built by forming all combinations of the variables and assigning a 0 or 1 weight to each combination as necessary for the function. For instance, any logical function of two logical variables P, and Q, can be constructed as:

$$LF = K_1PQ + K_2\underline{P}Q + K_3P\underline{Q} + K_4\underline{PQ}$$

Where:

1. PQ is TRUE when A AND B are both TRUE.
2. The underline means "not P", so $\underline{P}Q$ is TRUE when P is false AND Q is TRUE.
3. K_1, K_2, K_3, K_4 are assigned values of 1 or 0 as necessary for the desired logic.

For instance,

If $K_1 = 1$, and $K_2 = K_3 = K_4 = 0$, then the logic function (LF) is
$LF = PQ$, the "AND" function.

If $K_1 = K_2 = K_3 = 1$ and $K_4 = 0$, then
$LF = PQ + \underline{P}Q + P\underline{Q} = P + Q$, the "OR" function.

By identifying the necessary values of the K_is any logical function can be built. There are 2^N combinations of N variables, requiring values for that number of K_is. Thus, for 3 independent variables, there are 8 combinations; 4 independent variables, 16 combinations; and so forth. The analyst should use as few BQs as possible to avoid requiring processing of an unnecessarily large amounts of data.

Building a logic function requires collecting data for each K_i by determining what the logic function should equal for each input combination. Table 5 helps to visualize the process of building the logic for three inputs. Row 1 of the table identifies the eight combinations of the three input variables P, Q AND R. These variable are identified with particular BQ answers for each analysis. For instance, analyses that will be described subsequently, PQR are defined by BQs as follows:

P is TRUE when co/t A is within 2KM of the lead co/t D,
Q is TRUE when co/t B is within 2KM of the lead co/t D,
R is TRUE when co/t c is within 2KM of the lead co/t D.

In other analyses PQR defined by other BQs.

At each time interval (when mission data are sampled) one input combination of the input variables occurs. That combination and the to-be-predicted dependent variable data values are determined from the mission data file. For an illustration, hypothetical data has been entered into the table in row 2. In column 2, under combination "PQR", is the entry "T(6)" which is interpreted: the combination PQR occurred 6 times and on each occurrence the dependent variable was TRUE -- strong evidence that associated K_1 should equal 1. Similar evidence is illustrated in the 4th column under $P\underline{Q}R$ where the data say that combination occurred on 4 time intervals and on each occurrence the dependent variable was TRUE, indicating that K_3 should equal 1. Likewise, data for combination $PQ\underline{R}$, i.e., F(6), say that K_4 should equal 0, providing a FALSE logic value for that input.

No data were obtained for the last 4 columns, which may or may not be a problem. If the missions analyzed are truly representative of the general population of missions or the nature of the mission precludes the existence of those combinations (or their occurrence is likely rare), then since those combinations will not occur, the logic selected for them is of no consequence. The corresponding K_is could be set to either 1 or 0; however, they are typically set to 0. For example, if 10 independent variables are used, the number of combinations will be 1024; however, not all of these combinations will occur. Thus the logic can be built on just those combinations that do occur, resulting in a considerable simplification.

A safe alternative is to set them to an alert value of -1. If one of those combinations did occur, the -1 data value would alert the analyst that a combination has occurred for which there is no experience.

Table 5 Logic Analysis

Combination	PQR	$\underline{P}QR$	$P\underline{Q}R$	$PQ\underline{R}$	$\underline{PQ}R$	$\underline{P}Q\underline{R}$	$P\underline{QR}$	$\underline{PQR}$
K_i	K_1	K_2	K_3	K_4	K_5	K_6	K_7	K_8
Data for K_i	T(6)	T(5) F(1)	T(4)	F(6)				

Data collected in the third column, under $\underline{P}QR$, reveals an inconsistency in the dependent variable data when organized into the current combinations of independent variables. While the combination occurred 6 times, the dependent variable was inconsistent for those instances: in 5 time intervals, the dependent variable was TRUE and on one interval it was FALSE. When one dependent variable value frequency greatly exceeds the other, such as T(10) and F(1), the more frequent value is accepted i.e, T(10), and the associated K_i value set accordingly, i.e., K_i =1. Otherwise, when the relative frequency of dependent variable data are about equal, the associated K_i is given a probabilistic value equal to the probability of being a 1. This situation occurs often and permits use of the probabilistic logic to discriminate among levels of mission effectiveness.

The last case discussed, however, also offers the analyst the opportunity to refine the logic to more consistently predict the dependent variable. Refinements usually include adjustments to the BQ parameters or introduction of additional BQs as independent variables. Table 6 illustrates the introduction of additional BQs to better predict answers to the dependent BQ. For this example, suppose the analyst judges that the activity measured by the dependent variable changes as the mission objective is approached and that change is the reason for the inconsistent prediction of the dependent variable. The analyst decides to further decompose the mission space into regions each representing a different distance to the objective. For that purpose new BQs are specified establishing ranges from the TF to the objective. Three BQs use different parameter ranges (-20KM to -4KM, -4KM to -2KM, -2KM to 0) close to the objective. (For this example a negative distance indicates that the TF has not yet reached the objective.) As shown in Table 6, this decomposition with the additional BQs permits a more consistent prediction of the dependent variable.

Table 6 Extended Logic Analysis

Combination	PQR	$\underline{P}QR$	$P\underline{Q}R$	$PQ\underline{R}$	$\underline{PQ}R$	$\underline{P}Q\underline{R}$	$P\underline{QR}$	$\underline{PQR}$
K_i	K_1	K_2	K_3	K_4	K_5	K_6	K_7	K_8
BQ1 TRUE	T(4)	T(3)	T(3)	F(2)				
BQ2 TRUE	T(2)	T(2)		F(4)				
BQ3 TRUE		F(1)	T(1)					

KM = Kilometers
BQV_D = distance from TF lead co/t to the objective

BQ1 is TRUE when $-20KM < BQV_D \leq -4KM$
BQ2 is TRUE when $-4KM < BQV_D \leq -1KM$
BQ3 is TRUE when $-1KM < BQV_D \leq 0$

After the data collection, the analyst will compare the logics associated with different levels of mission effectiveness and identify the differences in the K_is. Only some K_is will likely be different as mission effectiveness varies. Consequently, the logic may be simplified. For instance, if the dependent variable changes value with mission effectiveness only when one distance to the objective is true, the other BQ for the other distance ranges need not be used for effectiveness prediction. Logic differences associated with effectiveness are combined with indicators from other analyses to form an overall effectiveness prediction.

As an illustration of the relationship of the Relative Analysis and an hypothesis, consider a possible hypothesis: The TF commanders of effective units will position themselves forward near the lead co/t as necessary to insure that company/teams (co/ts) are properly positioned for the attack. Less effective missions will not exhibit that logic. Specifically, the hypothesized logic is:

1. When the lead co/t is between <u>-20KM and -4KM</u> from the objective, the TF commander will move to within 2KM of the lead team only if the non-lead co/ts are not within 2KM of the lead co/t. Rationale: The TF commander does not need to be forward if the co/ts are close together and ready for the attack. The logic representation of this hypothesis is:

   $$E = \underline{P}QR + P\underline{Q}R + PQ\underline{R} + \underline{PQ}R + \underline{P}Q\underline{R} + P\underline{QR} + \underline{PQR} = \mathrm{NOT}(PQR)$$

   Where P = TRUE means that co/t A is within 2KM of the lead co/t. Similar interpretations hold for Q, AND R. If NTC data supports the logic function, then the hypothesis should not be rejected.

2. When the lead co/t is between <u>-4KM and -1KM</u> from the objective, the TF commander will move to within 2KM of the lead team only if more than one non-lead co/ts are not within 2KM of the lead co/t. Rationale: one co/t may be in overwatch position in this range cell, providing direct cover fire for the other co/ts, but the other co/ts should be within 2KM of the lead co/t. The logic representation of this hypothesis is:

   $$E = \underline{PQ}R + \underline{P}Q\underline{R} + P\underline{QR} + \underline{PQR}$$

3. When the lead co/t is between <u>-1KM and 0KM</u> from the objective, the TF commander will move to within 2KM of the lead team only if all of the non-lead co/ts are not within 2KM of the lead co/t. Rationale: The TF commander does not need to be forward if the co/ts are close together during the attack. The logic representation of this hypothesis is the same as for condition 1 above.

Table 7 shows the logic data that would support the hypothesis stated above.

Table 7 Extended Logic Analysis Hypothesis

Combination	PQR	$\underline{P}QR$	$P\underline{Q}R$	$PQ\underline{R}$	$\underline{PQ}R$	$\underline{P}Q\underline{R}$	$P\underline{QR}$	$\underline{PQR}$
K_i	K_1	K_2	K_3	K_4	K_5	K_6	K_7	K_8
BQ1 TRUE	F	T	T	T	T	T	T	T
BQ2 TRUE	F	F	F	F	T	T	T	T
BQ3 TRUE	F	T	T	T	T	T	T	T

KM = Kilometers
BQV_D = distance from TF lead co/t to the objective

BQ1 is TRUE when -20KM $< BQV_D \leq$ -4KM
BQ2 is TRUE when -4KM $< BQV_D \leq$ -1KM
BQ3 is TRUE when -1KM $< BQV_D \leq 0$

T/F entries in cells indicate that the commander is within 2KM of the lead co/t, i.e., a "T" indicates the commander needs to be within 2KM of the lead co/t to direct the attack. A "F" indicates that he does not need to be there.

Transition Analysis. The use of the state transition analysis assumes that effectiveness is a function of the sequence of states (conditions) rather than the states themselves. For example, the state sequence S1, S3 may be associated with more effective missions while the state sequence S1, S2 associated with less effective missions. The rationale is that assessment of performance is a function of what a unit does given the present state and is independent of how the unit arrived at that state. Assessment of performance that led to the present state is a function of the units behaviors at those previous states. While a generally effective unit's behaviors will generally lead to subsequent states favorable to effective mission outcomes, not all state transitions are under the control of the unit. Some state transitions may be due to factors the unit can control, but others may be due to factors outside the units direct control. Thus, on occasion, a generally effective unit may (due to enemy action, a difficult assignment, inadequate resources, unfavorable weather, or simply bad luck) find itself in a state not favorable to effective missions. Relating the behaviors of the unit given that state and the resulting degree of effectiveness is the domain of the state transition analysis.

Transition analysis has been the most useful of the three analysis methods described here. However, this analysis, as with the Relative Analysis, requires that the analyst carefully select the state variables, too many will require excessive data, but too few may ignore those variables needed to capture the critical mission conditions associated with mission effectiveness. This may require some "cut and try" experimentation with the variables. State variables selected for the Transition Analysis may be different than those selected for other analyses.

While the mission state is defined by the variables selected, the state variable data at each time sample must be coded in some way into a state number so that each possible combination of the state variables has a unique number. This coding is entirely artificial and the state numbers are only convenient state labels. If it is known beforehand which state variable combinations will actually occur, then a convenient coding is to simply assign a unique number to each combination, starting with 1 and continuing so that the last combination gets the number equal to the number of combinations. This coding method results in the least number of states which is very important for simplifying the analysis.

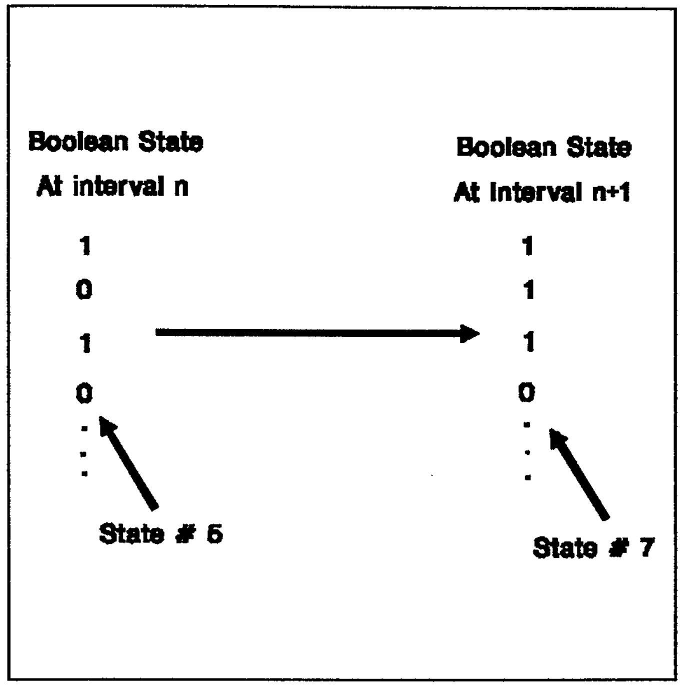

Figure 4 State Transition

However, before the state variable combinations that do occur become known, a convenient coding scheme is that shown in Figure 4. The coding treats the column of BTS data values at each time sample as a binary number. Thus, in Figure 4, row 1 is weighted by a 1, row 2 weighted by 2, row 3 weighted by 4, and so forth continuing with weights of 8, 16, 32, 64 etc. Thus, in the figure the state at interval n is defined by a 1 in row 1 and another 1 in row 3. Adding the weights for those rows gives 1+ 4 = 5. Consequently, that combination of BTS values is called "state 5". Likewise, the other state shown for interval n+1 is labeled "state 7".

Another way to assign state numbers is to number mission conditions believed to be important to effectiveness. Table 8 illustrates this method using a table from the Relative Analysis. With this method all possible states are initially assigned a number. Next, the analyst determines which states are actually used by a large set of missions. Then, the states are renumbered, assigning numbers to only those mission conditions that actually occur during one or more missions.

State transition analysis is a study of how state transition patterns are associated with different levels of mission effectiveness. For the analysis of a given type of mission, mission data are separated into groups according to mission effectiveness.

Table 8 Assigning State Numbers To Mission Conditions

Combination	PQR	$\underline{P}QR$	$P\underline{Q}R$	$PQ\underline{R}$	$\underline{PQ}R$	$\underline{P}Q\underline{R}$	$P\underline{QR}$	$\underline{PQR}$
K_i	K_1	K_2	K_3	K_4	K_5	K_6	K_7	K_8
BQ1 TRUE	1	2	3	4	5	6	7	8
BQ2 TRUE	9	10	11	12	13	14	15	16
BQ3 TRUE	17	18	19	20	21	22	23	24

KM = Kilometers
BQV_D = distance from lead co/t D vehicle to the objective
Conditions A, B, C are logical answers to BQs defining mission conditions.

BQ1 is TRUE when -20KM $< BQV_D \leq$ -4KM
BQ2 is TRUE when -4KM $< BQV_D \leq$ -1KM
BQ3 is TRUE when -1KM $< BQV_D \leq 0$

The number of groups possible depends on the number of missions for which data are available, but generally 7 to 10 missions in each group are sought. Then, the ADA transition analysis software, under analyst control, builds a transition matrix representing the transitions that occurred for during each mission in that effectiveness group.

The software reads the mission data file and records each transition as it occurs and when all missions of that group have been read, the transition counts are converted into transition probabilities, using a matrix such as that shown in Figure 5. Once the transition probabilities for each effectiveness group have been computed, the analyst compares the matrixes to identify the transitions that are associated with mission effectiveness. The transition probabilities found to be associated with mission effectiveness are then used with variables from other analyses to form a prediction of mission effectiveness.

SPECIFIC APPROACH

Mission Type

Deliberate Attack missions were selected for initial analysis of the NTC data. Data for 10 missions were made available for the analysis.

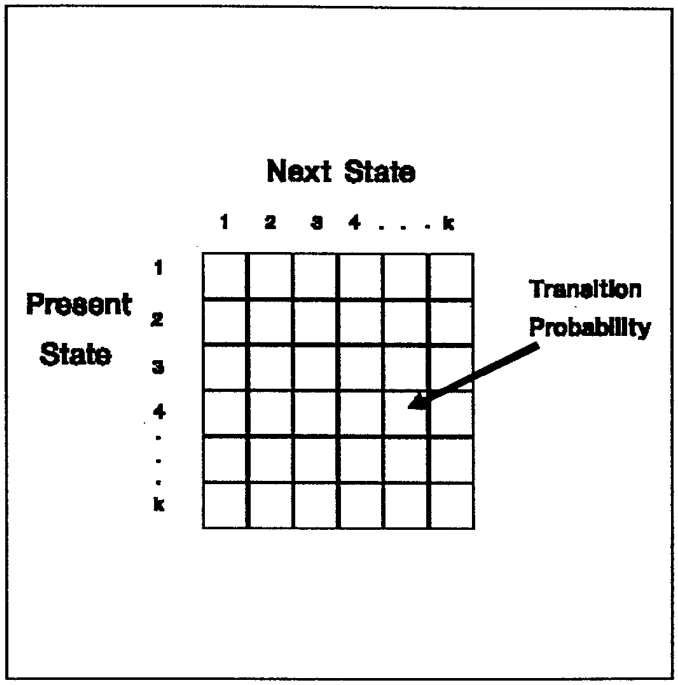

Figure 5 Transition Matrix

Hypotheses

We hypothesize that "effectiveness" is achieved by adequate or better performance on a <u>large number</u> of critical functions, rather than by high performance on single, isolated functions. We, therefore, would expect effective units to be distinguished from ineffective units, not so much in terms of performance of individual functions, as in the <u>pattern</u> of effective performance of a large number of functions. For Deliberate Attack missions, of the type examined in this research, critical functions may include effective positioning of scouts and their communication of needed intelligence to the commander; organization of the column during the march to facilitate the attack (e.g., positioning of engineers forward so they will be in position to clear obstacles); massing of forces during the attack phase; and so on. This concept guides the analysis in several ways:

1. The analyst must seek to determine the set of critical functions that must be performed sufficiently well to achieve a highly effective mission. Based on the above concept, high correlations of function performances with mission outcome effectiveness assessments are not expected until many of the critical functions are identified and tested together. Analysis starts by examining mission performances considered highly effective and identifying patterns of performances that consistently exist in those missions. Then, the frequency of those patterns in missions assessed as less effective is determined. Obviously, those performance patterns more consistently found in the missions rated as more effective are the candidates for the set of functions critical to mission effectiveness. This method avoids the piecemeal approach of attempting to correlate each individual task performance with mission outcome indicators, which can yield inconclusive results for two reasons; one reason is that an incomplete set of functions is analyzed; another reason is that indicators of mission effectiveness (i.e., an MOE) are used instead of a complete measure of mission effectiveness. Either reason is sufficient to yield inconclusive results.

2. The analyst must seek to determine operational definitions of criterion levels for the necessary function performances. BQs provide a convenient mechanism for implementing and testing the operational criterion levels. For instance, suppose that co/t dispersion is hypothesized to be one of the functions critical to TF effectiveness. Initially, multiple BQs are formed to identify various levels of dispersion. A common approach is to calculate the dispersion of a set of co/t performances rated very effective. Dispersion is measured during the approach march (dispersion during attack could be an additional set of BQs) as the standard deviation (SD) over the march time samples. Then, a set of BQs are formed for testing all units during the march over a range of dispersions levels:

    BQ1: true if 0.0 ≤ SD < 0.5xSDE
    BQ2: true if 0.5xSDE ≤ SD < 1.0xSDE
    BQ3: true if 1.0xSDE ≤ SD < 1.5xSDE
    BQ4: true if 1.5xSDE ≤ SD < 2.0xSDE etc.

    Where: SD is the standard deviation of the co/t being analyzed and

    SDE is the standard deviation of co/t performances rated very effective.

    While the large set of BQs would be used during the initial analyses, only one or two found to be representing the levels critical to unit effectiveness would be used in subsequent analyses.

3. Hypotheses are formed to guide the development of BQs. However, BQs are in fact operational definitions of the hypotheses. Consequently, any BQ refinements constitute a revision of the hypotheses. Thus, to insure that our testing strategy will apply to the general population of NTC missions, two sets of NTC data should be used. One set for analysis training, i.e., analyst learning about what function performances lead to effective missions. Another set is needed to estimate the statistical significance of the results obtained in the general population of NTC missions.

For purposes of this research effort, the following hypotheses were established:

1. Effective units will have less dispersion and will attack with a speed closer to a specified speed than less effective units.

2. Task Force commanders of effective units will be positioned to insure that co/ts will transition from march into attack formations to mass fire power at the point of attack.

PROCEDURES

General Analysis Procedure

Since the deliberate attack was the type of mission selected for this study, the procedure is described for that mission type. However, a similar procedure would be used to analyze other types of missions.

In order to conduct an analysis using the ADA system, the analyst must obtain some data files, the ARI-NTC Battle Trace Replay Software, and must prepare a mission file for each mission to be analyzed, as well as an analysis file. The step by step procedures for accomplishing the analysis are given in this section. Appendix A, which is organized as a handbook, contains supporting details of how to build each analysis data file.

1. Select a mission type such as deliberate attack, hasty defense, etc. Identify the missions to be included in the analysis. Obtain documentation for each mission. The documentation should include a description of the mission, its objectives, commander's intent and plans, and co/t makeups and their assigned functions.

2. Operate the ARI-NTC Battle Trace Replay software to observe the red and blue forces during the mission. Identify a mission objective point -- the location along the blue force path that is achieved just after breakthrough. The objective point may or may not correspond to any objective cited in the mission documentation. It is used here as a datum for setting a distance/state framework for describing TF activities through the mission. Accordingly, it should be set where an imaginary line connecting the forward red vehicles intercepts with the TF path. The TF path is the path observed on the replay screen or if terminated before red positions are reached, the projection of the TF path into the red area.

3. Select an action line which separates the TF initial position and the red defensive positions including the objective point. Some vehicles tracked by the NTC vehicle tracking system and assigned to co/ts do not move with their co/ts into the action. For instance, vehicles under repair may not move at all during the missions. Others may halt during the march and fail to move into firing range of the red force. Even though these vehicles are specified as members of a co/t, we do not want to include them in calculations of: team dispersion, average team distance to the objective point, and average team velocity.

   The action line is specified by selecting any 2 points along it. These points are defined by the X/Y map coordinates and are input to the BQ Processor in the mission file using the format specified in Appendix A (item "Mission File"). The precise location of the action line is not important. Vehicles that cross the line during the mission are included in the analyses. Those that do not cross the action line are not included in any BQ calculations.

4. After the action line coordinates are determined, a beginning point must also be determined. The precise location of the beginning point is not important. It is simply used to tell the processor which side of the action line the vehicles will start from. Consequently, it must be on the other side of the line from the objective point.

5. When the objective point and action line have been selected, the TF lead and lag vehicles must be identified. Some versions of the ARI NTC Battle Trace Replay software permit identification of the vehicles displayed using a mouse controlled pointer. If that function is available, it should be used to identify the lead and lag vehicles. However, without that capability a two-step process identifies the lead TF vehicle. In the first step, the lead co\team is identified and then in the second step, the lead vehicle within that team is found.

   The lead co/t is empirically identified using the ARI-NTC Battle Trace Replay Software, specifying the display of each co/t one-at-a-time, running the mission under manual control (where the time sample is updated with each keystroke) and noting when (i.e., the time sample) the lead vehicle of each team first reaches the objective point or comes to its closest distance from it. The co/t with the earliest time to reach the objective point is the lead co/t.

   Then, a search of the lead co/t vehicles is used to identify the lead vehicle, the first one to reach the objective. A binary search strategy is useful for identifying the lead vehicle within the lead co/t. A binary search is conducted as follows: using the ARI-NTC Battle Trace Replay Software, select, for display, half of the vehicles in the lead co/t. The other half is not displayed. Again, run the mission under manual control stopping when the first vehicle reaches the objective point. If the time sample displayed equals the time the first vehicle for the co/t arrived at the objective point recorded earlier, we conclude that the selected vehicles include the lead vehicle. If not, we conclude that the undisplayed half must include the lead vehicle. The half that does include the lead vehicle is itself divided in half and the ARI-NTC Battle Trace Replay software run again in manual mode. This process is repeated until the search narrows to a single vehicle which is the first to reach the objective point. The 3 character code identifying that vehicle is noted.

   A similar process is conducted to identify the lag vehicle, the vehicle that crosses the action line last. It may not reach the objective point.

Locations of the lead and lag vehicles are used to calculate the dynamics of the TF during the march, preparation for the attack, the attack, and the exploitation phases of the mission. Details of how the calculations are performed are given in Appendix A.

6. Build the mission data file to identify the co/t makeups, action line coordinates, objective point coordinates, starting point coordinates, and the lead and lag vehicle 3 character identifiers. A mission file is built for each mission used in the analysis. Appendix A identifies the format for the file which should be built in exactly that format. Any editor, such as a work processor editor, can be used to build the mission file; however, is must be saved as ASCII file, not the word processor file. Failure to save the mission file as an ASCII file will result in a read error when the BQ processor attempts to read the file. The mission file name is the mission base name with the suffix ".MIS" attached.

   The mission data file is used to define the individuals or teams that can be used in analyses. The ADA software will accept up to 10 groups, specified by the letters A through J. While the mission file defines each group by specifying the vehicles making up the group, one exception is "J" which always refers to the TF vehicles that participate in the mission (as described in the previous section #3 above, only vehicles crossing the action line are included in the mission analysis).

   While, except for group J which always designates the total TF, groups are defined in the mission data file, certain conventions are used in this report. Letters A, B, C, and D are used to designate co/ts identified in the mission documentation. Letters E and F are used to identify the TF commander and executive officer, respectively. The remaining letters were not used.

7. Build the analysis file. The analysis file specifies both the BQs and the co/ts the BQ will be applied to. Each analysis file defines an analysis and is used together with each mission file to provide the same analysis for each mission. Appendix A describes the analysis file format. A large number of analyses are possible using combinations of BQs, BQ parameters, and co/t mission data, each combination specified by an analysis file.

   BQ parameters specify the conditions for the BQ to be true.

   Initial analysis are designed to give the analyst a quantitative "movie" of the mission dynamics. Key BQVs which identify the mission state, such as distance of co/ts to the objective, are examined using a set of BQs that display the BQV value from the mission start to mission end. Parameters for that set of BQs are established as non-overlapping, so that for a given BQV only one BQ is true for any time sample. To accomplish this "coverage", the BQ with the most negative boundary is made less than the expected boolean variable value while the BQ with the most positive boundary is made more positive than the expected boolean variable value. For instance, if the distance to the objective point is expected to be no less than -15,000 meters, the most negative BQ boundary would be set at -20,000 meters. See Appendix A (section "Boolean Questions") for a discussion of positive and negative distances.

The "coverage" strategy for specifying BQ parameters, just described, applies to the initial analyses where the analyst is "getting familiar" with the method and the mission dynamics. BTSs provide a mission movie, an amplitude sampled picture of the various interworkings of the mission, specified by the analyst. For instance, co/t range to the objective uses a set of BQs whose amplitude samples display a "true" output for each amplitude level as the co/t approaches the objective point. However, once the analyst comes to understand the overall mission dynamics, interest is typically centered on just one or a few critical conditions of the variable. A critical condition might indicate when the co/t comes in direct fire range of the enemy, or when it reaches the objective point. Knowledge of the overall mission dynamics, obtained in the initial analyses, permits an understanding of the mission state, such as co/t locations, from just those few BTSs. The advantage of this coding is to remove unnecessary data from the display and permit, as the analysis proceeds to include more variables, a dense display of multiple mission variables.

Creation of the analysis can use any editor including a word processor. Similar to the mission file, the analysis file must be an ASCII file, with the name "ANALYSIS.YYY". The suffix YYY is selected by the analyst to identify a particular analysis.

8. Build a BASENAME File containing the file names of the missions to be analyzed. Up to 20 mission names can be put in the file at a time. The existing BASENAME file illustrates its format.

9. Form groups of missions categorized according to effectiveness ratings. For instance, excellent, good, and fair could be one set of effectiveness groups. Any number of performance groups can be established depending on the number of missions available. To support subsequent statistical analysis at least 7 to 10 missions should be in each group.

10. Run the ADA BQ Processor to generate the BTS files.

11. Run ADA analysis, "Relative" or "Transition" programs to read the BTS files and produce measures of mission dynamics patterns.

12. Combine pattern measures according to effectiveness groups established. For instance, highly effective missions may typically exhibit certain logic and/or transitions as a function of mission state. Compare group patterns to identify pattern differences that discriminate mission effectiveness.

Boolean Questions

Focusing on the subordinate hypothesis identified above, two types of BQs were computed as "tools" for implementing those hypotheses. One type is applied to co/ts while the other type is applied to the overall TF. BQs are defined by their analog variables (BQV) and the ranges assigned to form the question: does the BQV fall within the specified range? The BQVs that are applied to co/ts are:

1. Distance from team to the objective point,
2. Team velocity,
3. Team dispersion,
4. Distance of team members to team leader,
5. Number of team vehicles,
6. Distance between co/ts.

BQVs applied to the overall TF are:

7. Length of task force column,
8. Distance from front of column to objective point,
9. TF dispersion.

The calculations of these BQVs are described in the Appendix A.

Analyses Conducted

Two types of analyses were conducted using BQs as an initial step in assessing the hypotheses stated above. One type investigated the dynamics of the co/t commander's location relative to the co/t during the mission. The other type examined the relative dynamics of the co/ts during the overwatch and assault functions of the mission. As discussed in the Results Section, data describing the co/t makeup were available for 3 missions.

Individual co/t analysis. This analysis employed several types of BQs whose answers were computed as a function of mission time. The BQVs, which in part define the BQ, used for this analysis are as follows:

1. Distance of the co/t from the objective point (measured at each time sample by first calculating the mean of the co/t element positions and then determining the distance of that mean location to the objective),

2. Velocity of the co/t (measured as the mean velocity of co/t elements (KM/minute)),

3. Co/t dispersion (measured as the standard deviation of the team members from the co/t mean location),

4. Distance from the co/t location to its leader,

5. BQV 5 (number of co/t vehicles) is not used here, and

6. Distance between co/ts.

The distance of the co/t to the objective point is used in each analysis as a reference of events which helps interpreting other BTSs for that mission and comparing one mission performance to another.

Specific BQs used are defined in an analysis file, illustrated in Table 9, which specifies both the BQV and the range parameter criteria for the BQ. (Appendix A describes the analysis file format. A brief summary is given here.) Each table row contains data for 5 variables. Going from left to right along a row, the first variable is the BQ index number, identified in the list above; the second and third variables are the BQ lower and upper range parameter values; the fourth variable is the co/t ID; and the fifth variable is the BQV variable number. For example, BQ1, specified in row 1 of the table, will give a TRUE (i.e., true as used here does not mean a correct value rather than an incorrect value, but instead, refers to a logical TRUE rather than a logical FALSE answer) answer when: co/t A range to the objective point is greater than -20,000 meters and less than or equal to -9,000 meters.

Similarly, BQ2 specified in row 2 will be TRUE if the range is greater than -9000 meters and less than or equal to -8000 meters. Additional BQs are specified in the subsequent rows. Lines 41 through 60 specify a "0" for the parameter values and are not used in this analysis.

When BQV 6 (distance between co\teams) is specified, the fourth "variable" is actually two variables, i.e., two letter designations for the two co/ts involved. Table 10 illustrates this usage in rows 7 through 26.

A more complete description of analysis files and its format is given in Appendix A in the section titled "Analysis File". Four analysis files, one for each co/t in which the letter "A" is replaced by the appropriate co/t letter designation, were used in the analyses. As each analysis is conducted, the computer writes an output file providing the BTS for the co/t. These are described in the Results section that follows. A complete list of analysis files is given in Appendix C.

Table 9 Co/t Analysis File

File: ANALYSIS.A1A

BQ	Parameters		Co/t	BQV	
1	-20000	-9000	A	1	
2	-9000	-8000	A	1	
3	-8000	-7000	A	1	
4	-7000	-6000	A	1	
5	-6000	-5000	A	1	Indicate distance of Co/t A to the objective.
6	-5000	-4000	A	1	
7	-4000	-3000	A	1	
8	-3000	-2000	A	1	
9	-2000	-1000	A	1	
10	-1000	0	A	1	
11	0	1000	A	1	
12	1000	20000	A	1	
13	-1	5	A	2	
14	5	10	A	2	
15	10	20	A	2	Indicate velocity of Co/t A toward the objective.
16	20	30	A	2	
17	30	40	A	2	
18	40	50	A	2	
19	50	60	A	2	
20	-1	100	A	3	
21	100	200	A	3	
22	200	300	A	3	
23	300	400	A	3	
24	400	500	A	3	Indicate dispersion of Co/t A.
25	500	1000	A	3	
26	1000	1500	A	3	
27	1500	2000	A	3	
28	2000	2500	A	3	
29	2500	20000	A	3	
30	-20000	-2500	A	4	
31	-2500	-2000	A	4	
32	-2000	-1500	A	4	
33	-1500	-1000	A	4	
34	-1000	-500	A	4	Indicate distance between Co/t A and its leader.
35	-500	0	A	4	
36	0	1000	A	4	
37	1000	1500	A	4	
38	1500	2000	A	4	
39	2000	2500	A	4	
40	2500	20000	A	4	
41	0	0	J	0	
42	0	0	J	0	
43	0	0	J	0	
44	0	0	J	0	Not used in this analysis.
45	0	0	J	0	
46	0	0	J	0	
47	0	0	J	0	
48	0	0	J	0	
49	0	0	J	0	
50	0	0	J	0	
51	0	0	J	0	
52	0	0	J	0	
53	0	0	J	0	
54	0	0	J	0	
55	0	0	J	0	
56	0	0	J	0	
57	0	0	J	0	
58	0	0	J	0	
59	0	0	J	0	
60	0	0	J	0	

Note: The column headings and row underlines as well as the column format have been modified to facilitate description. Table C1 (File: ANALYSIS.A1) in Appendix C gives the correct format.

Table 10 Illustration of BQV 6 Usage

File: ANALYSIS.C1W

BQ	Parameters		Co/t	BQV	
1	-20000	-6000	C	1	
2	-6000	-4000	C	1	
3	-4000	-2000	C	1	Indicate distance of lead co/t, in
4	-2000	-1000	C	1	this case Co/t C, to the objective.
5	-1000	0	C	1	
6	0	20000	C	1	
7	-20000	-6000	CA	6	
8	-6000	-4000	CA	6	Indicate distance between Co/ts A and C.
9	-4000	-2000	CA	6	
10	-2000	-1000	CA	6	
11	-1000	20000	CA	6	
12	-20000	-6000	CB	6	
13	-6000	-4000	CB	6	Indicate distance between Co/ts B and C.
14	-4000	-2000	CB	6	
15	-2000	-1000	CB	6	
16	-1000	20000	CB	6	
17	-20000	-6000	CD	6	
18	-6000	-4000	CD	6	Indicate distance between Co/ts D and C.
19	-4000	-2000	CD	6	
20	-2000	-1000	CD	6	
21	-1000	20000	CD	6	
22	-20000	-6000	CE	6	
23	-6000	-4000	CE	6	Indicates distance between task force
24	-4000	-2000	CE	6	commander (E) and lead Co/t C.
25	-2000	-1000	CE	6	
26	-1000	20000	CE	6	

BQs 27 through 60 are not used for this analysis

BQ parameters used in the table above employ a coordinate system convention whereby the origin of the distance metric is set at zero at the objective. After a co/t reaches the objective and passes it, the distance is considered to be increasing (becoming more positive). Prior to reaching the objective but moving toward it, the co/t is also moving in the positive direction. However, when approaching the objective the absolute distance to the objective is decreasing. Thus, the mathematical representation defines the distance before the objective is reached to be negative and the distance after the objective is passed is positive. In terms of the BQ parameters, this means that -20000 meters from the objective is less positive than -9000 meters, or put in another way, -9000 meters is more positive than -20000 meters. The computer's interpretation of "more positive" is "greater than". Consequently, the BQ parameters are interpreted, referring the BQ1 of Table 9, BQ1 is true if the distance to the objective is more positive (greater than) -20000 meters and less positive (less than) -9000 meters.

<u>TF analyses.</u> TF analyses consists of an examination of the relative distance to the objective point of each co/t and indicators of the TF dynamics. BQ analog variables testing the TF dynamics, computed as a function of mission time, are as follows:

7. Length of the TF
8. Distance of the TF lead vehicle to the objective point
9. Dispersion of the TF

The TF analysis file is shown in Table 11. Descriptions of the calculations for these BQs are given in Appendix A in the section titled "Boolean Questions".

Table 11 TF Analysis File

File: ANALYSIS.TFA

BQ	Parameters		Co/t	BQV	
1	-20000	-7000	A	1	
2	-7000	-6000	A	1	
3	-6000	-5000	A	1	
4	-5000	-4000	A	1	
5	-4000	-3000	A	1	Indicate distance of Co/t A to the objective.
6	-3000	-2000	A	1	
7	-2000	-1000	A	1	
8	-1000	0	A	1	
9	0	1000	A	1	
10	1000	20000	A	1	
11	-20000	-7000	B	1	
12	-7000	-6000	B	1	
13	-6000	-5000	B	1	
14	-5000	-4000	B	1	
15	-4000	-3000	B	1	Indicate distance of Co/t B to the objective.
16	-3000	-2000	B	1	
17	-2000	-1000	B	1	
18	-1000	0	B	1	
19	0	1000	B	1	
20	1000	20000	B	1	
21	-20000	-7000	C	1	
22	-7000	-6000	C	1	
23	-6000	-5000	C	1	
24	-5000	-4000	C	1	
25	-4000	-3000	C	1	Indicate distance of Co/t C to the objective.
26	-3000	-2000	C	1	
27	-2000	-1000	C	1	
28	-1000	0	C	1	
29	0	1000	C	1	
30	1000	20000	C	1	
31	-20000	-7000	D	1	
32	-7000	-6000	D	1	
33	-6000	-5000	D	1	
34	-5000	-4000	D	1	
35	-4000	-3000	D	1	Indicate distance of Co/t D to the objective.
36	-3000	-2000	D	1	
37	-2000	-1000	D	1	
38	-1000	0	D	1	
39	0	1000	D	1	
40	1000	20000	D	1	
41	0	3000	J	7	
42	3000	4000	J	7	Indicate length of TF.
43	4000	6000	J	7	
44	6000	8000	J	7	
45	8000	20000	J	7	
46	-20000	-10000	J	8	
47	-10000	-8000	J	8	
48	-8000	-6000	J	8	
49	-6000	-4000	J	8	
50	-4000	-2000	J	8	Indicate distance of lead vehicle to the
51	-2000	-1000	J	8	objective.
52	-1000	-500	J	8	
53	-500	0	J	8	
54	0	500	J	8	
55	500	20000	J	8	
56	-10000	-5000	J	9	
57	-5000	-2000	J	9	
58	-2000	2000	J	9	Indicate TF dispersion.
59	2000	5000	J	9	
60	5000	10000	J	9	

Relative Analysis. Relative analysis seeks relationships that exist frequently with missions rated highly effective but exist less frequently with less effective units. The hypothesis selected to guide this analysis is the prediction of the TF commander's location with respect to each co/t as a function of mission state. Rationale is that commanders of effective missions will be in a position to insure that the teams are correctly positioned at each part of the mission. In particular, we hypothesize that commanders of units in effective missions will position themselves forward near the lead co/t as necessary to insure that co/ts are properly positioned for the attack. Less effective missions will not exhibit that logic. Positioning of the commander will depend on the positioning of the co/ts. The commander will be forward near the lead co/t if the other co/ts are not forward. However, if the supporting teams are in proper position, the commander will not move forward. Further, the commander's positioning logic will be a function of the distance of the TF from the objective, as discussed previously in the section on Relative analysis concepts.

To investigate this hypothesis four analysis files were developed, as listed in Table 12.

Table 12 Mission Analyses

	Review Analysis File	Test Analysis File
Mission M2	ANALYSIS.D1W (Table 13 and C7)	ANALYSIS.D1V (Table 14 and C9)
Mission M4	ANALYSIS.D1W (Table 13 and C7)	ANALYSIS.D1V (Table 14 and C9)
Mission M7	ANALYSIS.C1W (Table C6)	ANALYSIS.C1V (Table C8)

Tables C6, C7, C8 and C9 are in Appendix C

A review analysis file presents a movie of the variables of interest throughout the mission. It helps the analyst select BQ parameters for testing an hypothesis. After studying the review file, the analyst builds the test analysis file that contains BQs directly testing the mission data support of the hypothesis. ANALYSIS.D1W and ANALYSIS.C1W differ only in that different lead co/ts are specified. In the former co/t D is the lead while in the latter co/t C is the lead. Likewise, ANALYSIS.D1V and ANALYSIS.C1V differ only in respect to the lead co/t. Tables 13 and 14 present files ANALYSIS.D1W and ANALYSIS.D1V, respectively.

BQs shown in Table 13 rows 1 through 6 track co/t D as it approaches the objective. Next three sets of BQs, one for each non-lead co/t, track the relative distance between the specified co/t and the lead co/t. Finally, in rows 22 through 26, BQs track the relative distance between the lead co/t and the TF commander (coded as "co/t E"). Thus, the BTS produced with this analysis file displays a dynamic movie of those variables throughout the mission.

Table 13 Relation of Co/ts to Lead Co/t

File: **ANALYSIS.D1W**

BQ	Parameters		Co/t	BQV	
1	-20000	-6000	D	1	
2	-6000	-4000	D	1	
3	-4000	-2000	D	1	Indicate the distance of lead co/t to
4	-2000	-1000	D	1	objective.
5	-1000	0	D	1	
6	0	20000	D	1	
7	-20000	-6000	DA	6	
8	-6000	-4000	DA	6	Indicate the distance between lead co/t
9	-4000	-2000	DA	6	and co/t A
10	-2000	-1000	DA	6	
11	-1000	20000	DA	6	
12	-20000	-6000	DB	6	
13	-6000	-4000	DB	6	Indicate the distance between lead co/t
14	-4000	-2000	DB	6	and co/t B
15	-2000	-1000	DB	6	
16	-1000	20000	DB	6	
17	-20000	-6000	DC	6	
18	-6000	-4000	DC	6	Indicate the distance between lead co/t
19	-4000	-2000	DC	6	and co/t C
20	-2000	-1000	DC	6	
21	-1000	20000	DC	6	
22	-20000	-6000	DE	6	
23	-6000	-4000	DE	6	Indicate the distance between lead co/t
24	-4000	-2000	DE	6	and TF commander
25	-2000	-1000	DE	6	
26	-1000	20000	DE	6	

BQs 27 through 60 are not used for this analysis

Table 14 Boolean Questions Used in Relative and Transition Analysis

File: ANALYSIS.D1V

1	-20000	-4000	D	1	
2	-4000	-2000	D	1	Indicate distance of lead co/t to
3	-2000	0	D	1	objective.
4	-2000	2000	DA	6	
5	-2000	2000	DB	6	
6	-2000	2000	DC	6	Indicate relation of co/t and TF commander
7	-2000	2000	DE	6	to lead co/team D.

BQs 8 through 60 are not used for this analysis

After the analyst examined this mission movie, an additional analysis file was constructed to indicate only certain categories of the co/t D, and to test hypotheses concerning the relative distances between co/ts. In Table 14, rows 1 through 3 indicate three distances of the lead co/t (in this case co/t D) to the objective for testing the logic of a commanders position as a function of distance to the objective. Then, rows 4 through 7 test co/ts A,B,C,E distance to co/t D at each mission time sample. These BQs provide the data necessary to test the relative distance hypothesis stated above.

Transition Analysis. Transition Analysis uses the same data as the Relative Analysis, except for a different purpose. The hypothesis being tested is that: Column dispersion of effective units during the march will coalesce to provide mass direct fire and facilitate attack, breach, and breakthrough. Thus, the analysis seeks to detect patterns of co/t transitions that will result in a massing of firepower during the attack.

Specifically, we hypothesize that as the TF approaches the objective, measured by the distance of the lead co/t to the objective, the remaining co/ts will move to mass fire for the attack. This hypothesis was introduced in the Relative analysis concept section where the influence of distance to the objective was discussed. That hypothesis addressed the issue of the TF commanders positioning strategy as a function of mission conditions. The hypothesis used here employs the same data but addresses the coordination of co/ts to provide overwatch direct fire and then mass for the attack.

The hypothesis can be expressed by the preferred transitions for each of the three conditions relating the distance of co/t D to the objective as shown in Tables 15 and 16. In the tables, conditions P, Q, R are logical answers to BQs defining mission conditions:

P is TRUE when co/t A is within 2KM of the lead co/t D,
Q is TRUE when co/t B is within 2KM of the lead co/t D,
R is TRUE when co/t C is within 2KM of the lead co/t D.

Data analysis, then, consists of forming a transition matrix like that of Table 15 for each mission effectiveness category. For each effectiveness category, the number of transitions that occur in each transition matrix cell are counted. For instance if at one time sample, co/t A is not within 2KM of the lead co/t D but co/ts B and C are within that range then, according to the rules given above, P is FALSE and Q and R are TRUE. This condition is represented by the state "$\underline{P}QR$". If on the subsequent time sample co/ts A, B and C are within 2KM of the lead co/t, then the transition from state $\underline{P}QR$ to state PQR has occurred. That state transition would be recorded in the matrix cell on row $\underline{P}QR$ and column PQR. When the transitions of all missions in an effectiveness category have been entered into the matrix, the transition counts are converted into state transition probabilities by dividing the transition counts in each cell by the total number of transitions that occurred in its row. Finally, the analysis is completed by calculating the mean number of times each state is entered before the objective is reached, given a starting state. This calculation is performed by the analysis program: Transition. The mean number of state entries for each effectiveness category are compared and those that are associated with mission effectiveness are used as predictors of mission effectiveness.

Table 15 Favored Transitions For BQ1 or BQ3 TRUE

	PQR	$\underline{P}QR$	$P\underline{Q}R$	$PQ\underline{R}$	$\underline{PQ}R$	$\underline{P}Q\underline{R}$	$P\underline{QR}$	$\underline{PQR}$
PQR	✓							
$\underline{P}QR$	✓							
$P\underline{Q}R$	✓							
$PQ\underline{R}$	✓							
$\underline{PQ}R$	✓							
$\underline{P}Q\underline{R}$	✓							
$P\underline{QR}$	✓							
$\underline{PQR}$	✓							

Table 16 Favored Transitions For BQ2 TRUE

	PQR	$\underline{P}QR$	$P\underline{Q}R$	$PQ\underline{R}$	$\underline{PQ}R$	$\underline{P}Q\underline{R}$	$P\underline{QR}$	$\underline{PQR}$
PQR	✓							
$\underline{P}QR$		✓						
$P\underline{Q}R$			✓					
$PQ\underline{R}$				✓				
$\underline{PQ}R$	✓	✓	✓	✓				
$\underline{P}Q\underline{R}$	✓	✓	✓	✓				
$P\underline{QR}$	✓	✓	✓	✓				
$\underline{PQR}$	✓	✓	✓	✓				

RESULTS

Data Files

Data for 10 deliberate attack missions were made available for the project. However, several types of data problems depleted the number of serviceable mission data sets to just three. The major problem was not with the data files but with the lack of documentation defining the makeup of co/ts. Since the hypotheses dealt with the dynamics of co/ts, it was necessary to know beforehand the company units assigned to each co/t for the mission. One source on co/t makeup data was on unit take home videos which provided makeup data for missions M2, M4, and M7 shown in Table 17.

Table 17 Data Status

ID Code	METT-T INDEX	Co/t DATA STATUS
M1	64	DATA FILE PROBLEM
M2	7	OK
M3	19	DATA FILE PROBLEM
M4	14	OK
M5	19	TEAM ID NOT ON VIDEO TAPE
M6	58	TEAM ID NOT ON VIDEO TAPE
M7	63	DATA FOR TWO CO/TS (C & D) OK
M8	16	DATA FILE PROBLEM
M9	13	TEAM ID NOT ON VIDEO TAPE
M10	17	TEAM ID NOT ON VIDEO TAPE

(METT-T in this table is a measure of mission accomplishment, with a range of 0-100.) Once this documentation can be obtained for missions M5, M6, M9, and M10 their mission files can be prepared and their data analyzed. Mission data files for the remaining missions (M1, M3, and M8) contained inconsistencies that could not be resolved within the scope of this project.

Results of Individual Co/t Analyses

Co/t BTS. Results of the individual co/t analysis for Mission M2 are given here. Results for this analysis for the other missions are given in Appendix D. This mission attack plan calls for the four co/ts to attack in a diamond formation with Co/t D in the lead and Co/t B following. Co/ts A and C are on the side of the diamond. On approaching the objective point, Co/t A moves forward for the attack. The BTSs for the individual co/t analyses for Mission M2 are given in Tables 18 through 21 for co/ts A through D respectively. Interest is centered on the dynamics of each co/t during the march and attack.

Each table displays a movies of the mission variables specified by the BQs. Each row is associated with a particular BQ. The first two columns contain BQ parameters consisting of the lower and upper limits for a TRUE BQ answer. Column 3 identifies the co/t letter designation. Column 4 identifies the BQ type. Column 5 gives the row number which is also used as the BQ number - the number that corresponds to the BQ in the associated ANALYSIS file. That BQ number is repeated at the far right of the table. Between the BQ numbers is the plot of the BQ answers, displaying a "T" when the BQ parameter conditions are met, otherwise a blank or a presentation aid symbols are displayed. BQ answers for successive time samples are plotted horizontally across the row. Time sample numbers are given over and below the BQ answers. The analyst can soon develop a facility to directly read and interpret the BTS tables, although they may appear difficult at first.

Several different analyses are presented in each of the tables. Each analysis consists of a set of BQs of the same type applied to the same Co/t. The first analysis in Table 18 portrays Co/t A's distance to the objective (BQ type 1) with BQs 1 through 12. The second analysis shows Co/t A's velocity toward the objective (BQ type 2) using BQs 13 through 19. The third analysis shows the co/t's dispersion (BQ type 3) using BQs 20 through 29. Finally, the fourth analysis shows the distance between the co/team and its leader, using BQs 30 through 40. Similar analyses are shown for Co/ts B, C and D in Tables 19, 20 and 21, respectively.

Since Co/t D is the lead for the subject mission, its dynamics are examined first. The reader should refer back to Table 9, for explanation of the variables and their parameters, by BQ number. Interpreting the dynamics of Co/t D, shown in Table 21, the co/t starts movement toward the objective on time sample 3 and moves continuously to the objective reaching it at time sample 9. A large initial velocity of 50 to 60 KM/hr is demonstrated followed by a sustained velocity of 10 to 20 KM/hr to and past the objective. That velocity is maintained for 3 time samples (15 minutes) after the objective is passed. Team dispersion while large before the initial movement is reduced after movement onset until within 1000 meters of the objective where it suddenly jumps and increases till the end of mission. This may be due to team vehicles being disabled and unable to continue with the rest of the team, resulting in an increased dispersion since the disabled vehicles are included in the calculations. (If desired, the software could be modified to drop vehicles from this calculation if they had not moved for a given amount of time.)

The team leader is within 500 meters behind the co/t center (BQ 35 TRUE during time samples 3, 4 and 5) during the initial movement toward the objective. Then, as the objective is approached the leader moves behind the co/t so that just before the objective is reached the leader is 2000 to 2500 KM behind the co/t. Thereafter, the leader passes forward of the co/t position.

In contrast, Co/t A has a later start than Team D and arrived near the objective one time sample later. Further, team A's dispersion increases monotonically after the start of co/t movement, reaching a maximum near the objective point. This could be due to failure of vehicles to move or a general dispersion of the Team. Whatever the cause, it indicates that Co/t A was not able to effectively mass for the attack. Finally, the team leader was within 500 meters of the team center initially and then moved back to within 1000 meters of the team center during the approach. After the attack, the leader went forward of the team center and remained there till the end of the mission.

Co/t C started movement one time sample later (five minutes) than Co/t D, maintained a larger velocity during the approach, and arrived at and passed the objective point before Co/t D. Its velocity was maintained for another five time samples (25 minutes) after the objective point was crossed. Team dispersion was low at the attack but began to increase after passing the objective point, likely due to vehicle damage. Co/t leader moved in the center of the team through the march and attack but drifted to the rear after the team passed the objective point, possibly stopped due to enemy action.

Co/t B started movement three time periods (15 minutes) after that of Team D, maintained a velocity similar to that of the other teams, arriving at the objective point out three time samples after team D. Team dispersion was roughly constant throughout the mission and its leader followed the team center by 500 to 1000 meters throughout the mission.

Table 18 BTS for Mission M2, Co/t A, ANALYSIS.A1A

File: BTSM2.A1A

```
  LOWER    UPPER CO/T BQ     ROW
  BOUND    BOUND      TYPE   #           Time --------->
                                  000000000111111111122222222
                                  123456789012345678901234567
 -20000    -9000   A     1     1  TTT-|----|----|----|----|--   1
  -9000    -8000   A     1     2  ---T|----|----|----|----|--   2
  -8000    -7000   A     1     3  ----TT---|----|----|----|--   3
  -7000    -6000   A     1     4  ----|----|----|----|----|--   4
  -6000    -5000   A     1     5  ----|----|----|----|----|--   5
  -5000    -4000   A     1     6  ----|-T--|----|----|----|--   6  Distance to objective
  -4000    -3000   A     1     7  ----|--T-|----|----|----|--   7
  -3000    -2000   A     1     8  ----|----|----|----|----|--   8
  -2000    -1000   A     1     9  ----|---T|----|----|----|--   9
  -1000        0   A     1    10  ----|----T----|----|----|--  10
      0     1000   A     1    11  ----|----|----|----|----|--  11
   1000    20000   A     1    12  ----|----|TTTTTTTTTTTTTTTTT  12

     -1        5   A     2    13  TTT-|----|----|TTTTTTTTTT-T  13
      5       10   A     2    14  ----T----|----T----|----|T-  14
     10       20   A     2    15  ----|T-TTT-TT-|----|----|--  15
     20       30   A     2    16  ----|-T--|T--T|----|----|--  16  Velocity
     30       40   A     2    17  ---T|----|----|----|----|--  17
     40       50   A     2    18  ----|----|----|----|----|--  18
     50       60   A     2    19  ----|----|----|----|----|--  19

     -1      100   A     3    20  ----|----|----|----|----|--  20
    100      200   A     3    21  TTT-T----|----|----|----|--  21
    200      300   A     3    22  ----|----|----|----|----|--  22
    300      400   A     3    23  ----|T---|----|----|----|--  23
    400      500   A     3    24  ----|-T--|----|----|----|--  24  Dispersion
    500     1000   A     3    25  ---T|--T-|----|----|----|--  25
   1000     1500   A     3    26  ----|---T|----|----|----|--  26
   1500     2000   A     3    27  ----|----TT---|----|----|--  27
   2000     2500   A     3    28  ----|----|-TTTTTTTTTTTTTTTT  28
   2500    20000   A     3    29  ----|----|----|----|----|--  29

 -20000    -2500   A     4    30  ----|----|----|----|----|--  30
  -2500    -2000   A     4    31  ----|----|----|----|----|--  31
  -2000    -1500   A     4    32  ----|----|----|----|----|--  32
  -1500    -1000   A     4    33  ----|----|----|----|----|--  33
  -1000     -500   A     4    34  ---T|TTTT|----|----|----|--  34
   -500        0   A     4    35  TTT-T----|----|----|----|--  35  Relative position
      0     1000   A     4    36  ----|----|T---|----|----|--  36  of leader
   1000     1500   A     4    37  ----|----T----|----|----|--  37
   1500     2000   A     4    38  ----|----|----|----|----|--  38
   2000     2500   A     4    39  ----|----|----|----|----|--  39
   2500    20000   A     4    40  ----|----|-TTTTTTTTTTTTTTTT  40

                                  000000000111111111122222222
                                  123456789012345678901234567
```

TABLE 19 Mission M2, Co/t B, Analysis A1B

File: BTSM2.A1B

```
LOWER    UPPER  CO/T BQ    ROW
BOUND    BOUND       TYPE   #          Time ---------->
                                 000000000111111111122222222
                                 123456789012345678901234567
-20000   -9000   B     1      1  TTTTTT---|----|----|----|--  1
 -9000   -8000   B     1      2  ----|-T--|----|----|----|--  2
 -8000   -7000   B     1      3  ----|--T-|----|----|----|--  3
 -7000   -6000   B     1      4  ----|----|----|----|----|--  4
 -6000   -5000   B     1      5  ----|---T|----|----|----|--  5
 -5000   -4000   B     1      6  ----|----T----|----|----|--  6   Distance to objective
 -4000   -3000   B     1      7  ----|----|T---|----|----|--  7
 -3000   -2000   B     1      8  ----|----|----|----|----|--  8
 -2000   -1000   B     1      9  ----|----|-T--|----|----|--  9
 -1000       0   B     1     10  ----|----|----|----|----|-- 10
     0    1000   B     1     11  ----|----|--T-|----|----|-- 11
  1000   20000   B     1     12  ----|----|---TTTTTTTTTTTTTT 12

    -1       5   B     2     13  TTTTT----|----TTTTTTTTTTTTT 13
     5      10   B     2     14  ----|-TT-|----|----|----|-- 14
    10      20   B     2     15  ----|T---|T-TT|----|----|-- 15
    20      30   B     2     16  ----|---TT-T--|----|----|-- 16   Velocity
    30      40   B     2     17  ----|----|----|----|----|-- 17
    40      50   B     2     18  ----|----|----|----|----|-- 18
    50      60   B     2     19  ----|----|----|----|----|-- 19

    -1     100   B     3     20  TT--|----|----|----|----|-- 20
   100     200   B     3     21  --TTT-T--|----T-TTTTTTTTT-- 21
   200     300   B     3     22  ----|--TTT-T-T|T---|----|TT 22
   300     400   B     3     23  ----|----|----|----|----|-- 23
   400     500   B     3     24  ----|----|----|----|----|-- 24
   500    1000   B     3     25  ----|T---|T-T-|----|----|-- 25   Dispersion
  1000    1500   B     3     26  ----|----|----|----|----|-- 26
  1500    2000   B     3     27  ----|----|----|----|----|-- 27
  2000    2500   B     3     28  ----|----|----|----|----|-- 28
  2500   20000   B     3     29  ----|----|----|----|----|-- 29

-20000   -2500   B     4     30  ----|----|----|----|----|-- 30
 -2500   -2000   B     4     31  ----|----|----|----|----|-- 31
 -2000   -1500   B     4     32  ----|----|----|----|----|-- 32
 -1500   -1000   B     4     33  ----|T---|--TT|----|----|-- 33
 -1000    -500   B     4     34  ----|--TT|TT--TTTTTTTTTTTTT 34
  -500       0   B     4     35  -T-TT-T--|----|----|----|-- 35   Relative position
     0    1000   B     4     36  T-T-|----T----|----|----|-- 36   of leader
  1000    1500   B     4     37  ----|----|----|----|----|-- 37
  1500    2000   B     4     38  ----|----|----|----|----|-- 38
  2000    2500   B     4     39  ----|----|----|----|----|-- 39
  2500   20000   B     4     40  ----|----|----|----|----|-- 40

                                 000000000111111111122222222
                                 123456789012345678901234567
```

TABLE 20 Mission M2, Co/t C, Analysis A1C

FILE: BTSM2.A1C

```
 LOWER    UPPER  CO/T  BQ    ROW
 BOUND    BOUND        TYPE   #         Time --------->
                                  000000000111111111122222222
                                  123456789012345678901234567
-20000    -9000    C     1     1  TTT-|----|----|----|----|--  1
 -9000    -8000    C     1     2  ---T|----|----|----|----|--  2
 -8000    -7000    C     1     3  ----|----|----|----|----|--  3
 -7000    -6000    C     1     4  ----T----|----|----|----|--  4
 -6000    -5000    C     1     5  ----|----|----|----|----|--  5
 -5000    -4000    C     1     6  ----|T---|----|----|----|--  6   Distance to
 -4000    -3000    C     1     7  ----|-T--|----|----|----|--  7   objective
 -3000    -2000    C     1     8  ----|----|----|----|----|--  8
 -2000    -1000    C     1     9  ----|--T-|----|----|----|--  9
 -1000        0    C     1    10  ----|----|----|----|----|-- 10
     0     1000    C     1    11  ----|---T|----|----|----|-- 11
  1000    20000    C     1    12  ----|----TTTTTTTTTTTTTTTTTT 12

    -1        5    C     2    13  TTT-|----|----|-TT-TTTTTTTT 13
     5       10    C     2    14  ----|----|----|T--T|----|-- 14
    10       20    C     2    15  ----|TT--|-TTTT----|----|-- 15
    20       30    C     2    16  ---TT--TTTT---|----|----|-- 16   Velocity
    30       40    C     2    17  ----|----|----|----|----|-- 17
    40       50    C     2    18  ----|----|----|----|----|-- 18
    50       60    C     2    19  ----|----|----|----|----|-- 19

    -1      100    C     3    20  ----T----|----|----|----|-- 20
   100      200    C     3    21  ----|TT-T|----|----|----|-- 21
   200      300    C     3    22  ----|----|----|----|----|-- 22
   300      400    C     3    23  ----|----T----|----|----|-- 23
   400      500    C     3    24  TT--|----|----|----|----|-- 24   Dispersion
   500     1000    C     3    25  --T-|--T-|T---|----|----|-- 25
  1000     1500    C     3    26  ---T|----|-T--|----|----|-- 26
  1500     2000    C     3    27  ----|----|--T-|----|----|-- 27
  2000     2500    C     3    28  ----|----|----|----|----|-- 28
  2500    20000    C     3    29  ----|----|---TTTTTTTTTTTTTT 29

-20000    -2500    C     4    30  ----|----|--TTTTTTTTTTTTTTT 30
 -2500    -2000    C     4    31  ----|----|-T--|----|----|-- 31
 -2000    -1500    C     4    32  --T-|----|----|----|----|-- 32
 -1500    -1000    C     4    33  ----|----|T---|----|----|-- 33
 -1000     -500    C     4    34  TT-T|--T-T----|----|----|-- 34
  -500        0    C     4    35  ----T-T--|----|----|----|-- 35   Relative position
     0     1000    C     4    36  ----|T--T|----|----|----|-- 36   of leader
  1000     1500    C     4    37  ----|----|----|----|----|-- 37
  1500     2000    C     4    38  ----|----|----|----|----|-- 38
  2000     2500    C     4    39  ----|----|----|----|----|-- 39
  2500    20000    C     4    40  ----|----|----|----|----|-- 40

                                  000000000111111111122222222
                                  123456789012345678901234567
```

TABLE 21 Mission M2, Co/t D, Analysis A1D

FILE: BTSM2.AID

```
 LOWER    UPPER  CO/T BQ     ROW
 BOUND    BOUND       TYPE    #           Time --------->
                                  000000000111111111122222222
                                  123456789012345678901234567
-20000    -9000    D    1      1  TT--|----|----|----|----|--   1
 -9000    -8000    D    1      2  --T-|----|----|----|----|--   2
 -8000    -7000    D    1      3  ----|----|----|----|----|--   3
 -7000    -6000    D    1      4  ---T|----|----|----|----|--   4
 -6000    -5000    D    1      5  ----T----|----|----|----|--   5
 -5000    -4000    D    1      6  ----|----|----|----|----|--   6  Distance to
 -4000    -3000    D    1      7  ----|T---|----|----|----|--   7  objective
 -3000    -2000    D    1      8  ----|-T--|----|----|----|--   8
 -2000    -1000    D    1      9  ----|--T-|----|----|----|--   9
 -1000        0    D    1     10  ----|---T|----|----|----|--  10
     0     1000    D    1     11  ----|----|----|----|----|--  11
  1000    20000    D    1     12  ----|----TTTTTTTTTTTTTTTTTT  12

    -1        5    D    2     13  TT--|----|--TTTTT-TTTTTTTTT  13
     5       10    D    2     14  ----|----|----|----|----|--  14
    10       20    D    2     15  ---TTTTTTTTT--|--T-|----|--  15
    20       30    D    2     16  ----|----|----|----|----|--  16  Velocity
    30       40    D    2     17  ----|----|----|----|----|--  17
    40       50    D    2     18  ----|----|----|----|----|--  18
    50       60    D    2     19  --T-|----|----|----|----|--  19

    -1      100    D    3     20  ---T|--T-|----|----|----|--  20
   100      200    D    3     21  --T-T-T--|----|----|----|--  21
   200      300    D    3     22  ----|T---|----|----|----|--  22
   300      400    D    3     23  ----|----|----|----|----|--  23
   400      500    D    3     24  ----|----|----|----|----|--  24  Dispersion
   500     1000    D    3     25  ----|---T|----|----|----|--  25
  1000     1500    D    3     26  ----|----T----|----|----|--  26
  1500     2000    D    3     27  TT--|----|T---|----|----|--  27
  2000     2500    D    3     28  ----|----|-TTTTTT--|----|--  28
  2500    20000    D    3     29  ----|----|----|--TTTTTTTTTT  29

-20000    -2500    D    4     30  ----|----|----|----|----|--  30
 -2500    -2000    D    4     31  ----|--T-|----|----|----|--  31
 -2000    -1500    D    4     32  ----|---T|----|----|----|--  32
 -1500    -1000    D    4     33  ----|-T--T----|----|----|--  33
 -1000     -500    D    4     34  ----|T---|----|----|----|--  34
  -500        0    D    4     35  --TTT----|----|----|----|--  35  Relative position
     0     1000    D    4     36  ----|----|----|----|----|--  36  of leader
  1000     1500    D    4     37  TT--|----|----|----|----|--  37
  1500     2000    D    4     38  ----|----|T---|----|----|--  38
  2000     2500    D    4     39  ----|----|----|----|----|--  39
  2500    20000    D    4     40  ----|----|-TTTTTTTTTTTTTTTT  40

                                  000000000111111111122222222
                                  123456789012345678901234567
```

TF BTS. TF analysis, shown in Table 22, allows a comparison of the motion of each co/t as well as TF dynamics. The reader should refer back to Table 11 for explanation of the variables and their parameters, by BQ number. In that table, BQs 1 through 40 show the distance of each of the four co/ts (A, B, C, and D) to the objective. The BQs test the position of each co/t over a range of -20,000 meters (distance is negative when approaching the objective and positive after the objective is passed) to 20,000 meters. For each co/t, ten BQs quantify the range to the objective in non-overlapping categories, as specified in the TF analysis file ANALYSIS.TFA, shown in Table 11 and also in Table C7 of Appendix C. (All analysis files are collected in Appendix C.) As specified in the analysis file, BQ 8 indicates when Co/t A is within -1000 meters of the objective. BQ9 detects when the co/t has passed the objective and is still within 1000 meters of it. Thus, the transition of BQ8 being TRUE to BQ9 being True signals that co/t A has reached the objective. A similar indication occurs with the other co/ts. BQ pairs 18 & 19, 28 & 29, 38 & 39 indicate reaching the objective by co/ts B, C, and D, respectively. Inspection of Table 22 reveals that while Co/t D leads the approach to the objective for most of the approach, Co/t C, although starting later uses a higher velocity to pass the leader just before the objective and attacks the objective, reaching it by the 9th time sample. Co/t D reaches the objective shortly after, sometime during the 10th time sample. Co/t A reaches the objective during the 11th time sample. Then Co/t B, presumably providing overwatch support, arrives at the objective during the 13th time sample.

Considering the TF dynamics, recall that BQ types 7, 8, and 9 indicate <u>length of task force column</u>, <u>distance from front of column to objective point</u>, and <u>TF dispersion respectively</u>, as discussed in Appendix A. According to Table 22, BQs 41 through 45, TF length steadily increases during the approach and attack. TF dispersion starts at near zero, (BQ 59 and 60 bound zero dispersion) and increase during the approach march but becomes erratic after the objective is reached.

In contrast with Mission M2, the analysis of Mission M4 dynamics, shown in Table 23, shows that co/t B (apparently the lead vehicle) rapidly approaches the objective first, slows considerably, possibly to pass through obstructions not yet cleared by engineers, and then moves to the objective but not beyond it. The objective is reached during the 11th time sample. In contrast to the dynamics in Mission M2, the support co/ts in Mission M4 arrive near the objective late, at time samples 22, 24 and 23 for co/ts A, C and D, respectively.

Mission M7 dynamics are shown in Table 24. As noted previously, data for two co/ts appear to contain errors not yet corrected. However, Co/t D reaches the objective at time sample 16, while Co/t C does not quite reach the objective but stops at time sample 24. Due to the difficulties with the co/t A and B data, TF measures are not interpreted.

Table 22 BTS for Mission M2, TF

FILE: BTSM2.TFA

```
 LOWER    UPPER  CO/T BQ      ROW
 BOUND    BOUND       TYPE     #         Time ------>
                                   000000000111111111122222222
                                   123456789012345678901234567
-20000    -7000   A     1      1   TTTTTT---|----|----|----|--  1
 -7000    -6000   A     1      2   ----|----|----|----|----|--  2
 -6000    -5000   A     1      3   ----|----|----|----|----|--  3
 -5000    -4000   A     1      4   ----|-T--|----|----|----|--  4
 -4000    -3000   A     1      5   ----|--T-|----|----|----|--  5  Distance to
 -3000    -2000   A     1      6   ----|----|----|----|----|--  6  objective
 -2000    -1000   A     1      7   ----|---T|----|----|----|--  7
 -1000        0   A     1      8   ----|----T----|----|----|--  8
     0     1000   A     1      9   ----|----|----|----|----|--  9
  1000    20000   A     1     10   ----|----|TTTTTTTTTTTTTTTTT 10

-20000    -7000   B     1     11   TTTTTTTT-|----|----|----|-- 11
 -7000    -6000   B     1     12   ----|----|----|----|----|-- 12
 -6000    -5000   B     1     13   ----|---T|----|----|----|-- 13
 -5000    -4000   B     1     14   ----|----T----|----|----|-- 14
 -4000    -3000   B     1     15   ----|----|T---|----|----|-- 15  Distance to
 -3000    -2000   B     1     16   ----|----|----|----|----|-- 16  objective
 -2000    -1000   B     1     17   ----|----|-T--|----|----|-- 17
 -1000        0   B     1     18   ----|----|----|----|----|-- 18
     0     1000   B     1     19   ----|----|--T-|----|----|-- 19
  1000    20000   B     1     20   ----|----|---TTTTTTTTTTTTTT 20

-20000    -7000   C     1     21   TTTT|----|----|----|----|-- 21
 -7000    -6000   C     1     22   ----T----|----|----|----|-- 22
 -6000    -5000   C     1     23   ----|----|----|----|----|-- 23
 -5000    -4000   C     1     24   ----|T---|----|----|----|-- 24
 -4000    -3000   C     1     25   ----|-T--|----|----|----|-- 25  Distance to
 -3000    -2000   C     1     26   ----|----|----|----|----|-- 26  objective
 -2000    -1000   C     1     27   ----|--T-|----|----|----|-- 27
 -1000        0   C     1     28   ----|----|----|----|----|-- 28
     0     1000   C     1     29   ----|---T|----|----|----|-- 29
  1000    20000   C     1     30   ----|----TTTTTTTTTTTTTTTTTT 30

-20000    -7000   D     1     31   TTT-|----|----|----|----|-- 31
 -7000    -6000   D     1     32   ---T|----|----|----|----|-- 32
 -6000    -5000   D     1     33   ----T----|----|----|----|-- 33
 -5000    -4000   D     1     34   ----|----|----|----|----|-- 34
 -4000    -3000   D     1     35   ----|T---|----|----|----|-- 35  Distance to
 -3000    -2000   D     1     36   ----|-T--|----|----|----|-- 36  objective
 -2000    -1000   D     1     37   ----|--T-|----|----|----|-- 37
 -1000        0   D     1     38   ----|---T|----|----|----|-- 38
     0     1000   D     1     39   ----|----|----|----|----|-- 39
  1000    20000   D     1     40   ----|----TTTTTTTTTTTTTTTTTT 40

     0     3000   J     7     41   -TT-|----|----|----|----|-- 41
  3000     4000   J     7     42   ----|----|----|----|----|-- 42
  4000     6000   J     7     43   ---TTT---|----|----|----|-- 43 TF length
  6000     8000   J     7     44   ----|-TTTT----|----|----|-- 44
  8000    20000   J     7     45   ----|----|TTTTTTTTTTTTTTTTT 45

-20000   -10000   J     8     46   -T--|----|----|----|----|-- 46
-10000    -8000   J     8     47   ----|----|----|----|----|-- 47
 -8000    -6000   J     8     48   --TT|----|----|----|----|-- 48
 -6000    -4000   J     8     49   ----T----|----|----|----|-- 49
 -4000    -2000   J     8     50   ----|T---|----|----|----|-- 50  TF distance
 -2000    -1000   J     8     51   ----|-T--|----|----|----|-- 51  to objective
 -1000     -500   J     8     52   ----|----|----|----|----|-- 52
  -500        0   J     8     53   T---|----|----|----|----|-- 53
     0      500   J     8     54   ----|--T-|----|----|----|-- 54
   500    20000   J     8     55   ----|---TTTTTTTTTTTTTTTTTTT 55

-10000    -5000   J     9     56   ----|----|---T|--T-T---TT-T 56
 -5000    -2000   J     9     57   ----|-TTTTTTT-|----|----|-- 57
 -2000     2000   J     9     58   T-TTTT---|----|---T|-T--|T- 58  TF dispersion
  2000     5000   J     9     59   -T--|----|----|-T--|T-T-|-- 59
  5000    10000   J     9     60   ----|----|----TT---|----|-- 60
                                   000000000111111111122222222
                                   123456789012345678901234567
```

Table 23 BTS for Mission M4, TF

File: BTSM4.TFA

```
 LOWER    UPPER  CO/T BQ    ROW
 BOUND    BOUND       TYPE   #          Time ---------------->
                                 0000000001111111111222222222233333333334444
                                 1234567890123456789012345678901234567890123
-20000    -7000   A    1     1   TTTTTTTTTTTTT-|----|----|----|----|----|--- 1
 -7000    -6000   A    1     2   ----|----|---T|----|----|----|----|----|--- 2
 -6000    -5000   A    1     3   ----|----|----T----|----|----|----|----|--- 3
 -5000    -4000   A    1     4   ----|----|----|T---|----|----|----|----|--- 4
 -4000    -3000   A    1     5   ----|----|----|-T--|----|----|----|----|--- 5   Distance to
 -3000    -2000   A    1     6   ----|----|----|--T-|----|----|----|----|--- 6   objective
 -2000    -1000   A    1     7   ----|----|----|---TTT---|----|----|----|--- 7
 -1000        0   A    1     8   ----|----|----|----|-TTTTTTTTTTTTTTTTTTTTTT 8
     0     1000   A    1     9   ----|----|----|----|----|----|----|----|--- 9
  1000    20000   A    1    10   ----|----|----|----|----|----|----|----|--- 10

-20000    -7000   B    1    11   TTTTT----|----|----|----|----|----|----|--- 11
 -7000    -6000   B    1    12   ----|----|----|----|----|----|----|----|--- 12
 -6000    -5000   B    1    13   ----|T---|----|----|----|----|----|----|--- 13
 -5000    -4000   B    1    14   ----|----|----|----|----|----|----|----|--- 14
 -4000    -3000   B    1    15   ----|-T--|----|----|----|----|----|----|--- 15  Distance to
 -3000    -2000   B    1    16   ----|----|----|----|----|----|----|----|--- 16  objective
 -2000    -1000   B    1    17   ----|--TTT----|----|----|----|----|----|--- 17
 -1000        0   B    1    18   ----|----|TTTTTTTTTTTTTTTTTT-T----|----|--T 18
     0     1000   B    1    19   ----|----|----|----|----|---T|TTTTTTTTTTTT- 19
  1000    20000   B    1    20   ----|----|----|----|----|----|----|----|--- 20

-20000    -7000   C    1    21   TTTTTTT--|----|----|----|----|----|----|--- 21
 -7000    -6000   C    1    22   ----|--TT|----|----|----|----|----|----|--- 22
 -6000    -5000   C    1    23   ----|----T----|----|----|----|----|----|--- 23
 -5000    -4000   C    1    24   ----|----|TTT-|----|----|----|----|----|--- 24
 -4000    -3000   C    1    25   ----|----|---T|----|----|----|----|----|--- 25  Distance to
 -3000    -2000   C    1    26   ----|----|----TTTTTTTTT-|----|----|----|--- 26  objective
 -2000    -1000   C    1    27   ----|----|----|----|---TTTTTTTTTTTTTTTTTTTT 27
 -1000        0   C    1    28   ----|----|----|----|----|----|----|----|--- 28
     0     1000   C    1    29   ----|----|----|----|----|----|----|----|--- 29
  1000    20000   C    1    30   ----|----|----|----|----|----|----|----|--- 30

-20000    -7000   D    1    31   TTTTTTTTTTTTT-|----|----|----|----|----|--- 31
 -7000    -6000   D    1    32   ----|----|---TT----|----|----|----|----|--- 32
 -6000    -5000   D    1    33   ----|----|----|TTT-|----|----|----|----|--- 33
 -5000    -4000   D    1    34   ----|----|----|----|----|----|----|----|--- 34
 -4000    -3000   D    1    35   ----|----|----|---T|----|----|----|----|--- 35  Distance to
 -3000    -2000   D    1    36   ----|----|----|----T----|----|----|----|--- 36  objective
 -2000    -1000   D    1    37   ----|----|----|----|TT--|----|----|----|--- 37
 -1000        0   D    1    38   ----|----|----|----|--TT|----|----|----|--- 38
     0     1000   D    1    39   ----|----|----|----|----TTTTTT----|----|--- 39
  1000    20000   D    1    40   ----|----|----|----|----|----|TTTTTTTTTTTTT 40

     0     3000   J    7    41   ----|----|----|----TTTTTTTTTTTTTTTTTTTTTTTT 41
  3000     4000   J    7    42   ----|----|----|---T|----|----|----|----|--- 42
  4000     6000   J    7    43   --TTT----|----|TTT-|----|----|----|----|--- 43  TF length
  6000     8000   J    7    44   -T--|TTTTTTTTTT----|----|----|----|----|--- 44
  8000    20000   J    7    45   ----|----|----|----|----|----|----|----|--- 45

-20000   -10000   J    8    46   -T--|----|----|----|----|----|----|----|--- 46
-10000    -8000   J    8    47   --T-|----|----|----|----|----|----|----|--- 47
 -8000    -6000   J    8    48   ---T|----|----|----|----|----|----|----|--- 48
 -6000    -4000   J    8    49   ----T----|----|----|----|----|----|----|--- 49
 -4000    -2000   J    8    50   ----|T---|----|----|----|----|----|----|--- 50  TF distance
 -2000    -1000   J    8    51   ----|-T--|----|----|----|----|----|----|--- 51  to objective
 -1000     -500   J    8    52   ----|----|----|----|----|----|----|----|--- 52
  -500        0   J    8    53   T---|--TTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTT 53
     0      500   J    8    54   ----|----|----|----|----|----|----|----|--- 54
   500    20000   J    8    55   ----|----|----|----|----|----|----|----|--- 55

-10000    -5000   J    9    56   ----|----|-T--|----|----|----|----|----|--- 56
 -5000    -2000   J    9    57   ----|--T-|--TTTTTT-|----|----|----|----|--- 57
 -2000     2000   J    9    58   TTT-TTT--|----|---TTTTTTTTTTTTTTTTTTTTTTTTT 58  TF dispersion
  2000     5000   J    9    59   ---T|----|----|----|----|----|----|----|--- 59
  5000    10000   J    9    60   ----|---TTT---|----|----|----|----|----|--- 60
                                 0000000001111111111222222222233333333334444
                                 1234567890123456789012345678901234567890123
```

File: BTSM7.TFA

Table 24 BTS for Mission M7, TF

```
 LOWER    UPPER  CO/T BQ    ROW
 BOUND    BOUND       TYPE   #          Time --------------------->
                                 00000000011111111112222222222333333333344
                                 12345678901234567890123456789012345678901
-20000    -7000   A    1      1  ----|----|----|----|----|----|----|----|-  1
 -7000    -6000   A    1      2  ----|----|----|----|----|----|----|----|-  2
 -6000    -5000   A    1      3  ----|----|----|----|----|----|----|----|-  3
 -5000    -4000   A    1      4  ----|----|----|----|----|----|----|----|-  4
 -4000    -3000   A    1      5  ----|----|----|----|----|----|----|----|-  5  Distance to
 -3000    -2000   A    1      6  ----|----|----|----|----|----|----|----|-  6  objective
 -2000    -1000   A    1      7  ----|----|----|----|----|----|----|----|-  7
 -1000        0   A    1      8  ----|----|----|----|----|----|----|----|-  8
     0     1000   A    1      9  ----|----|----|----|----|----|----|----|-  9
  1000    20000   A    1     10  TTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTT 10

-20000    -7000   B    1     11  ----|----|----|----|----|----|----|----|- 11
 -7000    -6000   B    1     12  ----|----|----|----|----|----|----|----|- 12
 -6000    -5000   B    1     13  ----|----|----|----|----|----|----|----|- 13
 -5000    -4000   B    1     14  ----|----|----|--T-|----|----|----|----|- 14
 -4000    -3000   B    1     15  TTTTTTTTTTTTTT|----|----|----|----|----|- 15  Distance to
 -3000    -2000   B    1     16  ----|----|----|----|----|----|----|----|- 16  objective
 -2000    -1000   B    1     17  ----|----|----|----|----|----|----|----|- 17
 -1000        0   B    1     18  ----|----|----|----|----|----|----|----|- 18
     0     1000   B    1     19  ----|----|----|----|----|----|----|----|- 19
  1000    20000   B    1     20  ----|----|----TTT-TTTTTTTTTTTTTTTTTTTTTTT 20

-20000    -7000   C    1     21  TTTTTT---|----|----|----|----|----|----|- 21
 -7000    -6000   C    1     22  ----|-TTT|----|----|----|----|----|----|- 22
 -6000    -5000   C    1     23  ----|----TT---|----|----|----|----|----|- 23
 -5000    -4000   C    1     24  ----|----|-TT-|-TT-|----|----|----|----|- 24
 -4000    -3000   C    1     25  ----|----|---TTT--TT----|----|----|----|- 25  Distance to
 -3000    -2000   C    1     26  ----|----|----|----|TTT-|----|----|----|- 26  objective
 -2000    -1000   C    1     27  ----|----|----|----|---TTTTTTTTTTTT----|- 27
 -1000        0   C    1     28  ----|----|----|----|----|----|----|----|- 28
     0     1000   C    1     29  ----|----|----|----|----|----|----|----|- 29
  1000    20000   C    1     30  ----|----|----|----|----|----|----|TTTTTT 30

-20000    -7000   D    1     31  ----|----|----|----|----|----|----|----|- 31
 -7000    -6000   D    1     32  ----|----|----|----|----|----|----|----|- 32
 -6000    -5000   D    1     33  ----|----|----|----|----|----|----|----|- 33
 -5000    -4000   D    1     34  TTTT|----|----|----|----|----|----|----|- 34
 -4000    -3000   D    1     35  ----TT---|----|----|----|----|----|----|- 35  Distance to
 -3000    -2000   D    1     36  ----|-TTT|----|----|----|----|----|----|- 36  objective
 -2000    -1000   D    1     37  ----|----TT---|----|----|----|----|----|- 37
 -1000        0   D    1     38  ----|----|-TTTT----|----|----|----|----|- 38
     0     1000   D    1     39  ----|----|----|----|----|----|----|----|- 39
  1000    20000   D    1     40  ----|----|----|TTTTTTTTTTTTTTTTTTTTTTTTTT 40

     0     3000   J    7     41  ----|----|----|----|----|----|T-TTTTTTTTT 41
  3000     4000   J    7     42  ----|----|----|----|----TTTTTT-T--|----|- 42
  4000     6000   J    7     43  ----|----|----|TTTTTTTTT|----|----|----|- 43  TF length
  6000     8000   J    7     44  ----|----TTTTTT----|----|----|----|----|- 44
  8000    20000   J    7     45  -TTTTTTTT|----|----|----|----|----|----|- 45

-20000   -10000   J    8     46  ----|----|----|----|----|----|----|----|- 46
-10000    -8000   J    8     47  -TT-|----|----|----|----|----|----|----|- 47
 -8000    -6000   J    8     48  ---TT-T--|----|----|----|----|----|----|- 48
 -6000    -4000   J    8     49  ----|T-TTTTT--|----|----|----|----|----|- 49
 -4000    -2000   J    8     50  ----|----|--TTT----|----|----|----|----|- 50  TF distance
 -2000    -1000   J    8     51  ----|----|----|TTT-|----|----|----|----|- 51  to objective
 -1000     -500   J    8     52  ----|----|----|----|----|----|----|----|- 52
  -500        0   J    8     53  T---|----|----|----|----|----|----|----|- 53
     0      500   J    8     54  ----|----|----|----|----|----|----|----|- 54
   500    20000   J    8     55  ----|----|----|---TTTTTTTTTTTTTTTTTTTTTTT 55

-10000    -5000   J    9     56  ----|----|----|----|----|----|----|----|- 56
 -5000    -2000   J    9     57  ----|----|----|----|----|----|----|----|- 57
 -2000     2000   J    9     58  T---T--TT|----|----|--TTTTTTTTTTTTTTTTTTT 58  TF dispersion
  2000     5000   J    9     59  -TTT|TT--TTTTTTTTTTTTT--|----|----|----|- 59
  5000    10000   J    9     60  ----|----|----|----|----|----|----|----|- 60
                                 00000000011111111112222222222333333333344
                                 12345678901234567890123456789012345678901
```

Relative analysis

The Relative and Transition analyses provide tests of the hypothesis stated previously. That hypothesis is restated here in terms of BQ logic as follows: The TF commanders of effective units will position themselves forward near the lead co/t as necessary to insure that co/ts are properly positioned for the attack. Less effective missions will not exhibit that logic. Specifically, the hypothesized logic is:

1. When the lead co/t is between <u>-20KM and -4KM</u> from the objective, the TF commander will move to within 2KM of the lead team only if the non-lead co/ts are not within 2KM of the lead co/t. Rationale: The TF commander does not need to be forward if the co/ts are close together and ready for the attack. The logic representation of this hypothesis is:

   $$E = \underline{P}QR + P\underline{Q}R + PQ\underline{R} + \underline{PQ}R + \underline{P}Q\underline{R} + P\underline{QR} + \underline{PQR} = NOT(PQR)$$

   Where:

   P = TRUE if co/t A is within 2KM of the lead co/t.
   Q = TRUE if co/t B is within 2KM of the lead co/t.
   R = TRUE if co/t C is within 2KM of the lead co/t.
   E = is hypothesized logic of TF commanders positioning.

2. When the lead co/t is between <u>-4KM and -1KM</u> from the objective, the TF commander will move to within 2KM of the lead team only if more than one non-lead co/ts are not within 2KM of the lead co/t. Rationale: one co/t may be in overwatch position in this range cell, providing direct cover fire for the other co/ts, but the other co/ts should be within 2KM of the lead co/t. The logic representation of this hypothesis is:

   $$E = \underline{PQ}R + \underline{P}Q\underline{R} + P\underline{QR} + \underline{PQR}$$

3. When the lead co/t is between <u>-1KM and 0KM</u> from the objective, the TF commander will move to within 2KM of the lead team only if all of the non-lead co/ts are not within 2KM of the lead co/t. Rationale: The TF commander does not need to be forward if the co/ts are close together during the attack. The logic representation of this hypothesis is the same as for condition 1 above.

   If NTC data supports the logic function, then the hypothesis should not be rejected.

The Relative and Transition analyses files identified in Table 12 were used to produce the review and test BTS files identified in Table 25. The review BTS files were examined to determine if the hypothesis, as stated above, needs to be refined to improve the likelihood that the BQ parameters will discriminate mission effectiveness. In the ideal situation, multiple missions rated very effective would be available and their review files could be examined for that purpose.

Table 25 Mission Analyses

	Review BTS File	Test BTS File
Mission M2	BTSM2.D1W (Table 26 and D6)	BTSM2.D1V (Table 27 and D7)
Mission M4	BTSM4.D1W (Table D13)	BTSM4.D1V (Table D14)
Mission M7	BTSM7.C1W (Table D20)	BTSM7.C1V (Table D21)

Tables D6, D7, D13, D14, D20, D21 are given in Appendix D

Examination of the review BTS files, confirmed that the BQ parameters selected were potentially discriminating of mission effectiveness. The specific BQ parameters of interest are the -2000 to +2000 meter threshold for the distance between the lead co/t and the other co/ts and the TF commander. Reasons for the confirmation are twofold: One, it was the distance selected initially based on the concept that in that range all tanks would be in direct fire range when the lead co/t was with 2000 meters of enemy elements. Second, data in the available BTS tables showed considerable transition into and out of that distance, offering the possibility that the logic of the transitions could be discovered.

One of the three review BTS tables is shown in Table 26. These tables were designed to support conformation of the existing hypothesis and to provide data to refine the hypothesis if that is necessary. The first analysis (BQ 1 through 6) indicates the distance from the lead co/t to the objective, which lets us keep track of where the lead co/t is. The next four analyses using BQs 7 through 26 indicate the distance between co/ts A, B, C, and the TF commander. With these analyses the analyst evaluates the BQ parameters measuring distance between the lead co/t is frequently used during this and other missions.

Based on the analysis of the review files, analysis files "ANALYSIS.D1V and ANALYSIS.C1V" were built. Use of these analysis files produced the BTS test files listed in Table 25, i.e., the files with suffixes .D1V and .C1V. Table 27 is one of these files, indicating the TRUE or FALSE condition of each hypothesis test BQ at each lead co/t distance to the objective state. Data from Table 27 are collected for analysis in Table 28 for the M2 mission, and Tables 29 and 30 for the M4 and M7 missions, respectively.

To trace the analysis, observe in Table 27 that mission state indicated by BQ1 (row 1), which is TRUE when distance from co/t D is greater than -20000 but less than -4000 meters to the objective, is TRUE for five time samples, 1 through 5. In that mission state, the first two time samples (1 and 2), BQs 4, 5, 6 are T, T, F, respectively. (Lack of a "T" indicates an "F"). Further, BQ7 which indicates the distance of the TF commander is also F during those time samples. Since BQ 4 is a test of co/t A's distance, the logical P is TRUE, according to the definition given above. Likewise, since BQs 5 and 6 are T and F respectively, logical Q and R are set to T and F, respectively. Thus, the entry in Table 28 in column "PQ<u>R</u>" and row "BQ1 TRUE" is F(2). The "F" records the FALSE condition of the TF commander's position while the "2" records the number of times this combination of conditions occurred.

Continuing with extracting data from Table 27, data at time samples 3, 4, 5, and 6 all result in entries in the row where BQ1 is TRUE. At time sample 3, BQs 4, 5, 6 are all F, resulting in PQR all being F. Thus an "F(1)" is entered in Table 28 column <u>PQR</u>, since BQ7 is also F at that time interval. The analysis continues with data from each time sample being translated to the matrix in Table 28. Data from missions within an effectiveness performance category are combined in a matrix for that category.

Table 26 BTSM2.D1W

```
 LOWER    UPPER CO/T BQ     ROW
 BOUND    BOUND      TYPE    #          Time ------>
                                 000000000111111111122222222
                                 123456789012345678901234567
-20000    -6000   D    1      1 TTTT|----|----|----|----|--  1
 -6000    -4000   D    1      2 ----T----|----|----|----|--  2
 -4000    -2000   D    1      3 ----|TT--|----|----|----|--  3  Indicate distance of
 -2000    -1000   D    1      4 ----|--T-|----|----|----|--  4  lead co/t D to
 -1000        0   D    1      5 ----|---T|----|----|----|--  5  the objective
     0    20000   D    1      6 ----|----TTTTTTTTTTTTTTTTTT  6

-20000    -6000   DA   6      7 ----|----|----|----|----|--  7
 -6000    -4000   DA   6      8 ----|----|----|----|----|--  8  Indicate distance
 -4000    -2000   DA   6      9 --T-TTT--|----|----|----|--  9  between co/t A and
 -2000    -1000   DA   6     10 ---T|--TTTTTT-|----|----|-- 10  lead co/t D
 -1000    20000   DA   6     11 TT--|----|---TTTTTTTTTTTTTT 11

-20000    -6000   DB   6     12 ----|----|----|----|----|-- 12
 -6000    -4000   DB   6     13 ---TTTTTTTTTTT|TTTTTTTTTTTT 13  Indicate distance
 -4000    -2000   DB   6     14 --T-|----|----T----|----|-- 14  between co/t B and
 -2000    -1000   DB   6     15 ----|----|----|----|----|-- 15  lead co/t D
 -1000    20000   DB   6     16 TT--|----|----|----|----|-- 16

-20000    -6000   DC   6     17 ----|----|----|----|----|-- 17
 -6000    -4000   DC   6     18 ----|----|----|----|----|-- 18  Indicate distance
 -4000    -2000   DC   6     19 --TT|----|----|----|----|-- 19  between co/t C and
 -2000    -1000   DC   6     20 ----TT---|----|----|----|-- 20  lead co/t D
 -1000    20000   DC   6     21 TT--|-TTTTTTTTTTTTTTTTTTTTT 21

-20000    -6000   DE   6     22 ----TTTTTTTTTTTTTTTTTTTTTTT 22
 -6000    -4000   DE   6     23 ---T|----|----|----|----|-- 23
 -4000    -2000   DE   6     24 TTT-|----|----|----|----|-- 24  Indicate distance
 -2000    -1000   DE   6     25 ----|----|----|----|----|-- 25  between TF commander
 -1000    20000   DE   6     26 ----|----|----|----|----|-- 26  and co/t D
                                 000000000111111111122222222
                                 123456789012345678901234567
```

TABLE 27 BTSM2.D1V

```
 LOWER   UPPER CO/T BQ    ROW
 BOUND   BOUND      TYPE   #          Time ------->
                              000000000111111111122222222
                              123456789012345678901234567
-20000   -4000   D    1    1 TTTTT----|----|----|----|--  1  Indicates distance
 -4000   -2000   D    1    2 ----|TT--|----|----|----|--  2  of lead co/t D to
 -2000       0   D    1    3 ----|--TT|----|----|----|--  3  the objective

 -2000    2000  DA    6    4 TT-T|--TTTTTTTTTTTTTTTTTTTT  4  Tests co/t A
                                                             hypothesis
 -2000    2000  DB    6    5 TT--|----|----|----|----|--  5  Tests co/t B
                                                             hypothesis
 -2000    2000  DC    6    6 ----TTTTTT----|----|----|--  6  Tests co/t C
                                                             hypothesis
 -2000    2000  DE    6    7 ----|----|----|----|----|--  7  Tests TF commander
                              000000000111111111122222222    hypothesis
                              123456789012345678901234567
```

Results of the Relative Analysis are given in Tables 28, 29, and 30 where the entries are the number of time samples the TF commander's position was consistent (logic was TRUE) or inconsistent (logic was FALSE) for the mission conditions that occurred. Data for the tables were collected from the analyses listed in Appendix B but limited to the data from the mission start till the leading co/t reached the objective point. Since Tables 28 and 29 are missions with low METT-T scores, they could be combined into a single table. However, they are kept separate here to show individual results.

Tables 28 and 29 show only False indications since in both cases the commander was not within 2K meters of any of the co/ts under any the mission conditions that occurred. As additional missions are analyzed the matrices for each level of effectiveness can be completed and compared to assess if the commanders positioning during the attack influences the mission effectiveness.

The following conditions are used in the tables:

BQ1 is TRUE when -20KM $< BQV_D \leq -4$KM

BQ2 is TRUE when -4KM $< BQV_D \leq -1$KM

BQ3 is TRUE when -1KM $< BQV_D \leq 0$

P is TRUE when co/t A is within 2KM of the lead co/t D,

Q is TRUE when co/t B is within 2KM of the lead co/t D,

R is TRUE when co/t c is within 2KM of the lead co/t D.

Where Km = Kilometers

BQV_D = distance from lead co/t D vehicle to the objective

Table 28 Mission M2 Relative Analysis

Combination	PQR	$\underline{P}QR$	$P\underline{Q}R$	$PQ\underline{R}$	$\underline{PQ}R$	$\underline{P}Q\underline{R}$	$P\underline{QR}$	$\underline{PQR}$
K_i	K_1	K_2	K_3	K_4	K_5	K_6	K_7	K_8
BQ1 TRUE				F(2)	F(1)		F(1)	F(1)
BQ2 TRUE			F(2)		F(2)			
BQ3 TRUE								

Data file: BTSM2.D1V

Table 29 Mission M4 Relative Analysis

Combination	PQR	$\underline{P}QR$	$P\underline{Q}R$	$PQ\underline{R}$	$\underline{PQ}R$	$\underline{P}Q\underline{R}$	$P\underline{QR}$	$\underline{PQR}$
K_i	K_1	K_2	K_3	K_4	K_5	K_6	K_7	K_8
BQ1 TRUE					T(1)		T(13)	T(3) F(1)
BQ2 TRUE	T(1)				F(1)			
BQ3 TRUE	T(4)							

Data file: BTSM4.D1V

Table 30 Mission M7 Relative Analysis

Combination	D	D	D	$\underline{D}$	D	$\underline{D}$	$\underline{D}$	$\underline{D}$
K_i	K_1	K_2	K_3	K_4	K_5	K_6	K_7	K_8
BQ1 TRUE								T(9) F(6)
BQ2 TRUE								F(8)
BQ3 TRUE		F(1)						

Data file: BTSM7.C1V

Transition analysis

Tables 31, 32, and 33 give the transitions for two missions, M2 and M4, for which complete data were available. Recall that position data for Co/ts A and B of Mission M7 are believed to contain errors, and therefore, data for that mission are not included in the table. Table entries consist of the mission identification followed by the number of the indicated transitions that occurred. For instance, in Table 31 the entry in cell (PQR, PQR) "M4,11", indicates that Mission M4 remained in state PQR for 11 time samples. In general, transition matrix entries along the matrix diagonal are the number of time samples the mission was in that state. Off diagonal entries are the number of transitions from the state indicated by the row to the state indicated by the column.

Transitions for missions with similar performance ratings are combined as those shown in Tables 31, 32 and 33. Both these missions are rated low according to their METT-T ratings. A comparison of the data for Missions M2 and M4, shown in the tables, suggests that even though they are both rated low according the METT-T score, Mission M4 exhibits multiple transitions considered favorable. For instance, in Table 32, shows a transition from state PQR to PQR, a transition considered favorable because it indicates a massing of the co/ts for the attack. Table 33 shows "transitions", from state PQR to PQR, a transition to itself, which indicates the maintenance of a favorable state over multiple time samples. In contrast, Mission M2 does not exhibit transitions considered favorable. Thus, Mission M4 performance is considered better due to that evidence. When missions rated very effective are analyzed, a better scale for identifying the transitions critical to mission effectiveness can be developed. Critical transitions are those exhibited in effective missions that are not exhibited in less effective missions.

When data from a large number of missions are analyzed and entered into the matrices, the entries are divided by the row totals to obtain transition probabilities. Then the mean number of times each state is entered before the objective is reached is calculated. According to the assessment strategy discussed over, the mean number of state entries are compared to identify those associated with mission effectiveness. Those that are associated with mission effectiveness become mission effectiveness discriminators.

Table 31 Transitions For BQ1 TRUE, Missions M2 and M4

	PQR	$\underline{P}QR$	$P\underline{Q}R$	$PQ\underline{R}$	$\underline{PQ}R$	$\underline{P}Q\underline{R}$	$P\underline{QR}$	$\underline{PQR}$
PQR								
$\underline{P}QR$		M4,11						M2,1
$P\underline{Q}R$								
$PQ\underline{R}$				M2,1				M2,1
$\underline{PQ}R$							M7,7	
$\underline{P}Q\underline{R}$								
$P\underline{QR}$					M2,1			M4,1
$\underline{PQR}$				M4,1			M2,1	M4,1

Conditions A, B, C are logical answers to BQs defining mission conditions.
i.e., A is TRUE when co/t A is within 2KM of the lead co/t.

Table 32 Transitions For BQ2 TRUE, Missions M2 and M4

	PQR	$\underline{P}QR$	$P\underline{Q}R$	$PQ\underline{R}$	$\underline{PQ}R$	$\underline{P}Q\underline{R}$	$P\underline{QR}$	$\underline{PQR}$
PQR								
$\underline{P}QR$								
$P\underline{Q}R$								
$PQ\underline{R}$								
$\underline{PQ}R$	M4,1				M2,1			
$\underline{P}Q\underline{R}$								
$P\underline{QR}$								
$\underline{PQR}$								

Table 33 Transitions For BQ3 TRUE, Missions M2 and M4

	PQR	$\underline{P}QR$	$P\underline{Q}R$	$PQ\underline{R}$	$\underline{PQ}R$	$\underline{P}Q\underline{R}$	$P\underline{QR}$	$\underline{PQR}$
PQR	M4,3							
$\underline{P}QR$								
$P\underline{Q}R$								
$PQ\underline{R}$				M2,1				
$\underline{PQ}R$								
$\underline{P}Q\underline{R}$								
$P\underline{QR}$								
$\underline{PQR}$								

CONCLUSIONS & RECOMMENDATIONS

Status

The present state of the ADA methodology provides the software to read ARI NTC data files, to implement a set of BQs designed to test movement to the objective portion of an attack missions, to generate BTS data files for each analysis, and to analyze those BTS data files. This system can be used to form multiple hypotheses and to analyze a large number of attack missions testing those hypotheses. By doing so the analyst would develop information on attack processes that lead to effective and also ineffective attack missions. In addition, familiarity with the ADA thus gained would lead to suggestions as to how to improve ADA.

Once deliberate attack missions have been analyzed, improvements in the ADA system can be specified, and applications to other types of missions considered. Both the improvements and applications to new types of missions will likely require additional software programming.

Conclusions

1. Boolean analysis can be used to extract mission effectiveness information from the ARI NTC data base for analyst review and automated data analysis.

2. Method allows considerable flexibility in combining co/ts, BQ, and Boolean question parameters. The analyst can adjust, modify, and create new BQs with some ease and flexibility. BQs adjustments are made by modifying the BQ parameters. Existing BQs are modified and new BQs created by defining co/ts, selecting different BQVs, and by modifying the BQ parameters. Information on how to accomplish these tasks are given in Appendix A.

3. Use of data files allows automatic documentation of analyses, and the repeated use of analyses.

4. Simple and complex analysis can be gradually built to assess Co/t and TF performance. Some complex analyses can be built by creating more complex co/ts. For instance, an existing co/t can be converted into a new co/t that includes engineers by simply adding the engineer's vehicles to the list of co/t members. Also, one or more scout "co/ts" can be created to include their function into the analysis. If a new type of BQ is needed, i.e., beyond the 7 variables described in this report (see Appendix A for list and description), minor additional programming will be required.

5. Analysis can be applied to any organization level - individual vehicle, platoon, co/t, TF.

Problems that occurred during the project:

1. The major problem encountered during this project was the difficulty in identifying the makeup of co/ts from available documentation.

2. Some data files with the same mission name contained inconsistent data.

3. The METT-T score appears to address only a part of mission success. It does not account for variations in force, and environmental conditions. And does not consider various possible mission goals.

Recommendations

1. A recommended solution to the co/t makeup problem is to gather the participants at ARI/Monterey (the analyst, BQ developer, Military consultant) along with the data base archivists in Monterey to identify near and long term analyses to be conducted, establish measurement objectives, determine what data are readily available, identify alternative data that might be available (and could be used where primary data are not available), collect and interpret data as required. Then, any additional BQs needed can be coded, mission and analysis files developed, and analyses conducted. The goal is to have 10-15 missions for assessment of and refinement of hypotheses and then 10 missions to formally test hypotheses.

   Enlarging the number of missions for analysis requires that the analyst obtain the .PL and .PLC data files for the mission and obtain information on the co/t organizations for the mission. At present, up to 20 missions can be analyzed at one time. This is the limitation of the number of file names that can be read from file "BASENAME". However, the number of files that can be analyzed is virtually unlimited because the filenames listed in file "BASENAME" can be replaced any number of times.

2. Enhance display and control of computer programs based on feedback from users.

3. Develop BTS to display data unit performance data for take home package. Automated analysis can be applied at various levels: linking of cause and effect

hypotheses, linking performance effects from one organization level to another, as well as linking mission processes to mission outcomes.

4. Conduct analysis to relate mission process measurements to outcome measures.

5. Use enhanced measure of unit effectiveness which can assess effectiveness of a variety of mission objectives.

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Appendix A

Automated Data Analyzer

Boolean Question Processor

BOOLEAN QUESTION PROCESSOR

The Boolean Question (BQ) Processor reads input files containing mission player position data, calculates the answers to boolean questions specified by the analyst user, and writes output files containing BTS time sequences.

This appendix provides a description of the variables and files used by the BQ Processor -- the appendix is intended to be a "handbook" for the processor. It includes an example of each type of data file. The actual files used are included in the appendices that follow.

Input Files

To accomplish those analyses, the Boolean Question Processor asks for and accepts the mission identification name which uniquely identifies the mission to be analyzed and is used as a base name to which suffixes are added to read specific mission data files. As illustrated in Figure A1, several data files are then read by the processor which use the mission name as base file name ("xxxx" in the figure) plus a suffix. One data file, with suffix ".PL", identifies the elements tracked during the mission. A tracked element is typically a vehicle, referred to as an element here. Another data file uses the ".PLC" suffix provides the location of each element on each time block, which are typically five minute intervals. The third data file uses the ".MIS" suffix provides mission specific information needed to guide the analysis.

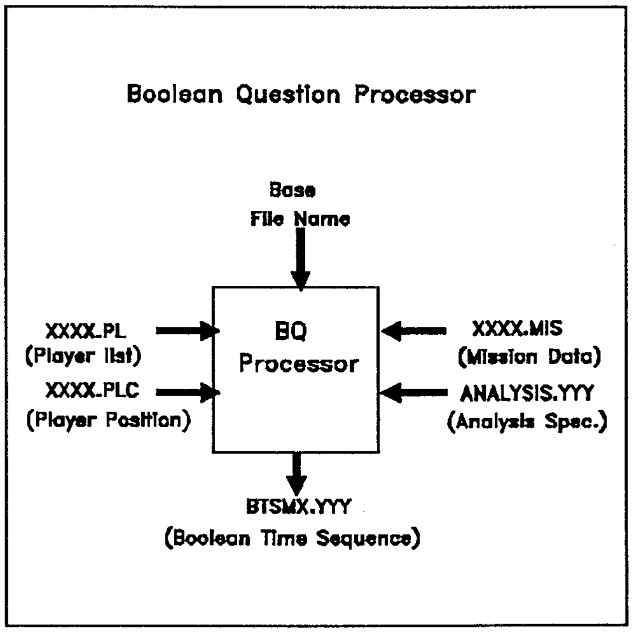

Figure A1 BQ Processor Files

A fourth file read by the processor is named the "analysis.yyy" file which specifies the analysis to be conducted by identifying the BQs to be used, their parameters, and specifies Co/team the BQs will be applied to. A particular analysis file is applied to multiple missions so that the same analysis can be conducted with a set of missions of the same type, such as a deliberate attack, hasty defense, etc.

Output files

An Boolean Time Sequence (BTS) file is written for examination by the analyst and for analysis by the ADA system.

DESCRIPTION OF ANALYSES AND DATA FILES

Each of the files identified above is described in the following paragraphs. In addition, certain analyses which are performed using the file data or needed to write output files are described prior to the file description.

File xxxx.PL

This file is part of the ARI-NTC Battle Trace Replay Software supplied by ARI for the project. Table A1 lists a portion of a .PL file

There are 6 data columns in the file. Column 1 gives a unique element 3-alphanumeric identifier physically marked on the element (usually a vehicle). Column 2 is a unique number assigned to the element by the database. The vehicle type is identified by the number listed in column 3. Initial element X,Y location coordinates are given in columns 4 and 5, respectively. Finally, Column 6 gives the red (R) or blue (B) membership of the element.

Table A1 Listing of a .PL File

730	29	4	80500	71500	R
720	31	4	80750	71250	R
110	33	3	39438	96238	R
111	34	3	38975	96075	R
112	35	3	38338	96313	R
113	36	3	47650	98350	R
114	37	3	39800	95275	R
115	38	3	39475	95938	R
117	39	3	47638	98350	R
120	40	3	37975	89888	R
121	41	3	37963	89613	R
122	42	3	37850	90075	R
124	43	3	38138	93925	R
125	44	3	38313	93638	R
127	45	3	47650	98350	R
130	46	3	39275	95250	R
131	47	3	47588	98388	R
132	48	3	47600	98413	R
134	49	3	37225	95100	R
136	51	3	39625	95538	R
150	52	3	39788	96063	R
210	53	3	80250	88000	R
211	54	3	80750	71500	R
212	55	3	80250	86500	R
215	57	3	80250	86750	R
217	58	3	80750	86750	R

File XXXX.PLC

This file is also part of the ARI-NTC Battle Trace Replay Software supplied by ARI for the project. Table A2 lists a portion of a .PLC file which contains 4 columns of data. Column 1 gives the time block (hours/minutes) for its row of data. Column 2 is an index number for the elements, it is referred to here as the element PLC number. Columns 3 and 4 are the X, Y coordinates of the vehicle referred to in the row, for the indicated time.

The PLC file starts with a listing of all element locations for the initial mission time. In Table A2, for example, the initial time is 6 hours and 0 minutes. Then, all element locations for the next time block are listed, usually at 5 minute intervals. Table A2 gives only the first 30 element locations to illustrate the file structure and since the file is very long to conserve space.

Table A2 XXXX.PLC File

06:00	1	8050	7150
06:00	2	8075	7125
06:00	3	3943	9623
06:00	4	3897	9607
06:00	5	3842	9635
06:00	6	4765	9835
06:00	7	3980	9527
06:00	8	3947	9593
06:00	9	4763	9835
06:00	10	3797	8988
06:00	11	3796	8961
06:00	12	3785	9007
06:00	13	3813	9392
06:00	14	3831	9367
06:00	15	4765	9835
06:00	16	3927	9525
06:00	17	4758	9838
06:00	18	4760	9841
06:00	19	3745	9510
06:00	20	3963	9553
06:00	21	3973	9603
06:00	22	8025	8800
06:00	23	8075	7150
06:00	24	8025	8650
06:00	25	8025	8675
06:00	26	8075	8675
06:00	27	8175	8625
06:00	28	8025	8625
06:00	29	8150	8625
06:00	30	8125	7250

Data in the .PL and .PLC files are related by the PLC number. That number is listed explicitly in the XXXX.PLC file and is implied by the row sequence in the XXXX.PL file.

Preliminary Mission Analysis

The analysis described in this section is conducted by the analyst prior to running the BQ Processor software.

A mission analysis data file is developed for each particular mission. The purpose of the data file is to provide information about the specific mission that will pérmit all missions of a given type to be analyzed the same way. Thus, for example on attack missions, the location of the objective must be specified so that its capture can be detected. Likewise, the make up of the Co/teams must be specified so the analysis can assess team performance such as dispersion, location of team leaders and so forth. The point is that the form of the mission file is a function of the type of mission - different mission type will require different information - and that each mission (i.e., each demonstration) will have its own mission file.

To obtain the needed information, the analyst will examine unit movement data using the ARI-NTC Battle Trace Replay software, after action reviews (video tapes and printed documentation), and mission planning documentation. The following paragraphs describe each of the data items needed for the mission file.

Co/team make up, the elements assigned to each co/team for the mission, is needed for the analyses. These data are found in the unit planning documents and in after action review video tapes.

The location of the mission objective point is also required. Boolean questions (BQ) ask for information that is keyed to the distance to the objective. Hence, the objective location must be specified. For instance, some boolean questions ask for the distance from Co/teams to the objective. Other boolean questions ask about the state of unit formations and the initiation of direct fire as a function of range to the objective. Still other BQ (for the deliberate attack type of mission) ask other questions needing distance to the objective data.

The analyst views the dynamic mission presentation provided by the Battle Trace Replay software to observe the red and blue forces during the mission and identifies a mission objective point -- the location along the blue force path that is achieved just after breakthrough. The objective point may or may not correspond to any objective cited in the mission documentation. It is used here as a datum for setting a distance/state framework for describing TF activities throughout the mission. Accordingly, it should be set where an imaginary line connecting the forward red vehicles intersects with the TF path. The TF path is the path observed on the replay screen or if terminated before red positions are reached, the projection of the TF path into the red area.

The analyst also selects an action line which separates the TF initial position and the red defensive positions including the objective point. Some vehicles tracked by the NTC vehicle tracking system and assigned to co\teams do not move with their co\teams into the action. For instance, vehicles under repair may not move at all during the missions. Others may halt during the march and fail to move into firing range of the red force. Even though these vehicles are specified as members of a co\team we do not want to include them in some co/team calculations, such as calculations of team dispersion, average team distance to the objective point, and average team velocity.

Selection of any two points, by their X/Y map coordinates, along the action line specified the line. The precise location of the action line is not of critical importance. Vehicles that cross the line during the mission are included in the analyses, while those that do not cross the action line are excluded from any of the BQ calculations.

After specifying the action line, a beginning point is identified. The precise location of the beginning point is not important, since it is used only to tell the processor which side of the action line the vehicles will start from. Consequently it must be on the other side of the action line from the objective point.

In addition, the TF lead and lag vehicles must be identified. The TF lead vehicle leads the TF to the objective. Some versions of the ARINTC Battle Trace Replay software permit identification of the vehicles displayed using a mouse controlled pointer. However, without that capability a two step process identifies the lead TF vehicle. In the first step, the lead co\team is identified and then in the second step, the lead vehicle within that team is found.

The lead co\team is empirically identified, using the Battle Trace Replay software, by specifying the display of one co\team one at a time, running the mission under manual control (where the time sample is updated with each keystroke) and noting when the lead element of each team first reaches the objective point or comes to its closest distance from it. The co\team with the earliest time to reach the objective point is the lead co\team.

Then, a search of the lead co\team vehicles is used to identify the lead vehicle, the first one to reach the objective. A binary search strategy is useful for identifying the lead vehicle within the lead co\team. A binary search is conducted as follows: using the replay software, select, for display, half of the vehicles in the lead co\team. The other half are not displayed. Again run the mission under manual control stopping when the first vehicle reaches the objective point. If the time sample displayed equals the co\team early time then the set of vehicles selected includes the lead vehicle. If not, the undisplayed set includes the lead vehicle. The set with the lead vehicle is again divided in half and the replay software run again in manual mode. This process is repeated until the search narrows to a single vehicle which is the first to reach the objective point. The 3 character code identifying that lead vehicle is noted.

A similar process is conducted to identify the lag vehicle, the vehicle that crosses the action line last. It may or may not reach the objective point.

Locations of the lead and lag vehicles are used to calculate the dynamics of the TF during the march, preparation for the attack, the attack, and the exploitation phases of the mission.

File xxxx.MIS

An example of the mission file is shown in Table A3. The mission file itself is the column of entries at the left of the table. Explanations of the entries are given to the right. Those entries are not part of the file and are not included in it.
The file format should be exactly as shown in the table.

Table A3 MISSION DATA FILE (FILENAME.MIS)

File data	Meaning of file data
4	Number of CO/Teams
1	Team # 1
13	Number of elements in team
A	Letter code for team
A60	First team element (always team leader)
A11	Second team element, etc.
A12	
A13	
A14	
A21	
A22	
A23	
A24	
A31	
A32	
A33	
A34	
2	Team # 2
13	(data have same meanings as above)
B	
B60	
B11	
B12	
B13	
B14	
B21	
B22	
B23	
B24	
B31	
B32	
B33	
B34	
3	Team # 3
13	(data have same meanings as above)
C	
60C	
10C	

(Table A3 Continued)

11C	
12C	
13C	
20C	
21C	
22C	
23C	
D21	
D22	
D23	
D24	
4	Team # 4
13	(data have same meanings as above)
D	
D60	
D11	
D12	
D13	
D14	
D31	
D32	
D33	
D34	
30C	
31C	
32C	
33C	
3200,9000,3200,9500,2800,9000,3625,9000	
D12B24	
	Next-to-the-last row contains four pairs of x-y may coordinates. The first two pairs establish an "action line" . The third pair is the beginning point for the mission and the final pair identifies the mission objective point selected.
	Finally, the 3 character codes for the lead and lag vehicles are specified.

Boolean Questions (BQ)

A boolean question is formed using a boolean question variable (BQV), a real variable whose value is calculated by a formula. For instance, one BQV, distance from a co/team to the objective point, is calculated as the distance of the mean team position to the objective point. A boolean question is formed by asking if the BQV satisfies specified criteria. For example, one BQ might ask if the BQV is less than 10,000 meters and greater than 9,000 meters.

BQVs are updated at each 5 minute time sample and therefore are constant throughout the 5 minute interval. Velocity is calculated for the 2nd time sample till the end of the mission since the first time sample is used to determine the change in distance over the 5 minute interval. Thus, no velocity data is available for the 1st time sample.

The BQVs are described in this section. The criteria for transforming the BQV into the BQ are specified in the analysis file which is described subsequently.

Calculation of each BQV is described as follows:

BQV applied to co/teams:

1. <u>Distance from team to the objective point</u> is the distance from the mean position of co/team elements to the objective point. Co/team elements used in the calculation include all elements specified in the mission file(.MIS) that cross the action line, except for the leader, whose position is calculated separately. Distance to the objective is positive if the mean team X coordinate is less than that of the objective position, otherwise it is negative.

2. <u>Team velocity</u> is the velocity of the mean team position. It is calculated as distance traveled divided by the time interval (a five minute interval). It is always positive independent of the direction traveled and its dimension is computed in Kilometers per minute (KM).

3. <u>Team dispersion</u> is the standard deviation of the distance of team elements from the mean team position. Team elements who do no cross the action line and the team leader are not included in the calculation.

4. <u>Distance of team elements to team leader</u> is the distance of the mean team position to the team leader's position. The team leader is always identified as the first entry for the team in the mission data file. Team elements who do no cross the action line are not included in the calculation.

5. The number of vehicles assigned to each co/team in the mission (.MIS) file.

6. Distance between to co/teams is computed as the distance between the mean positions of the co/teams.

BQV applied to the overall TF:

7. The length of task force column is the distance between the lead and lag vehicles.

8. Distance from front of column to objective point is the distance from the TF lead vehicle to the objective point.

9. TF dispersion is a measure of the width of the TF column. This calculation requires a reference path which is taken as the recent path of the lead vehicle established by the lead vehicle's present and previous positions, as shown in Figure A2. Dispersion is defined as the mean of the distribution of the distance (distance D shown in Figure A2) of each TF element (that crossed the action line) from the lead vehicle reference path.

   An alternate definition of the TF dispersion is the standard deviation of the distribution.

File: Analysis.yyy

Each analysis is defined by an analysis file which specifies the BQVs to be used, the parameters used to form the BQ, and the co/team the BQ is to be applied to. As shown in Table A4, the file consists of specifications arranged in rows, each of which specifies an individual BQ. Up to 60 BQ can be specified in the file. As shown in the following table, each row consists of 6 entries, some of which may not be used for a particular analysis. Columns 1 and 2 provide an index number for the rows. Next, two sets of 7 columns define the lower and upper (upper bound is exclusive) bounds for the BQ answer to be true. For instance in row 1, the lower bound is -20000 while the upper bound is -9000 (meters). If the BQV is within those bounds, the BQ answer "T" is output.

Next, two columns identify co/team letter designations. The first of these columns is used only when the last column is a "6" which specifies calculation of the relative distance between two co/teams is entered in the last column of the row. Thus, in that case, these two columns indicate the two co/teams involved. For instance, in Table A5, row 7 specifies that the distance between co/teams C and A is to be computed and if the result is greater than (more positive) than -20,000 meters and less than or equal to -6,000 meters, the boolean answer is true.

This distance calculation is typically applied to the co/teams defined for the mission; however, the calculation device can also be used for other purposes. An artificial co/team can be defined as any individual or group desired. We defined a co/team to be the TF commander, designated as "co/team E". The TF executive officer is designated as "co/team F". In this way the distance between these officers and other TF elements can be tested during the mission. In Table A5, rows 22 through 26 specify such BQs.

The last 2 columns in the analysis files specify the type of BQ to be used in the analysis. Note that while each analysis file consists of 60 rows, each row actually specifies the BQ for the corresponding row of the BTS file.

Please note that the table name at the top of the page and the page number is <u>not</u> part of the data file.

Table 4 File: Analysis.A1A

BQ	Parameters		Co/t	BQV	
1	-20000	-9000	A	1	Indicate distance of Co/t A to the objective.
2	-9000	-8000	A	1	
3	-8000	-7000	A	1	
4	-7000	-6000	A	1	
5	-6000	-5000	A	1	
6	-5000	-4000	A	1	
7	-4000	-3000	A	1	
8	-3000	-2000	A	1	
9	-2000	-1000	A	1	
10	-1000	0	A	1	
11	0	1000	A	1	
12	1000	20000	A	1	
13	-1	5	A	2	Indicate velocity of Co/t A toward the objective.
14	5	10	A	2	
15	10	20	A	2	
16	20	30	A	2	
17	30	40	A	2	
18	40	50	A	2	
19	50	60	A	2	
20	-1	100	A	3	Indicate dispersion of Co/t A.
21	100	200	A	3	
22	200	300	A	3	
23	300	400	A	3	
24	400	500	A	3	
25	500	1000	A	3	
26	1000	1500	A	3	
27	1500	2000	A	3	
28	2000	2500	A	3	
29	2500	20000	A	3	
30	-20000	-2500	A	4	Indicate distance between Co/t A and its leader.
31	-2500	-2000	A	4	
32	-2000	-1500	A	4	
33	-1500	-1000	A	4	
34	-1000	-500	A	4	
35	-500	0	A	4	
36	0	1000	A	4	
37	1000	1500	A	4	
38	1500	2000	A	4	
39	2000	2500	A	4	
40	2500	20000	A	4	
41	0	0	J	0	Not used in this analysis.
42	0	0	J	0	
43	0	0	J	0	
44	0	0	J	0	
45	0	0	J	0	
46	0	0	J	0	
47	0	0	J	0	
48	0	0	J	0	
49	0	0	J	0	
50	0	0	J	0	
51	0	0	J	0	
52	0	0	J	0	
53	0	0	J	0	
54	0	0	J	0	
55	0	0	J	0	
56	0	0	J	0	
57	0	0	J	0	
58	0	0	J	0	
59	0	0	J	0	
60	0	0	J	0	

Note: The column headings and row underlines as well as the column format have been modified to facilitate description. Table C1 (File: ANALYSIS.A1) in Appendix C gives the correct format.

Table A5 File: ANALYSIS.C1W

BQ	Parameters		Co/t	BQV	
1	-20000	-6000	C	1	
2	-6000	-4000	C	1	
3	-4000	-2000	C	1	Indicate distance of lead co/t, in
4	-2000	-1000	C	1	this case Co/t C, to the objective.
5	-1000	0	C	1	
6	0	20000	C	1	
7	-20000	-6000	CA	6	
8	-6000	-4000	CA	6	Indicate distance between Co/ts A and C.
9	-4000	-2000	CA	6	
10	-2000	-1000	CA	6	
11	-1000	20000	CA	6	
12	-20000	-6000	CB	6	
13	-6000	-4000	CB	6	Indicate distance between Co/ts B and C.
14	-4000	-2000	CB	6	
15	-2000	-1000	CB	6	
16	-1000	20000	CB	6	
17	-20000	-6000	CD	6	
18	-6000	-4000	CD	6	Indicate distance between Co/ts D and C.
19	-4000	-2000	CD	6	
20	-2000	-1000	CD	6	
21	-1000	20000	CD	6	
22	-20000	-6000	CE	6	
23	-6000	-4000	CE	6	Indicates distance between task force
24	-4000	-2000	CE	6	commander (E) and lead Co/t C.
25	-2000	-1000	CE	6	
26	-1000	20000	CE	6	

BQs 27 through 60 are not used for this analysis

File: BTS

BTS files are produced by the ADA processor. BTS data files are viewed by analysts to better understand the dynamics and relationships of mission variables and are also read by the analysis programs to detect patterns relevant to mission effectiveness.

The answers a BQ can change at each time sample. So that over the mission, as conditions change, the answers to a BQ consists of a row of T/F answers. The analysis system supports up to 60 BQs. Results are presented in a matrix with 60 rows and a number of columns equal to the number of time samples, each column providing the BQ answers for that time sample.

BTS data files are named as "BTSMX.YYY", where the "X" is replaced with the mission identification number and the "YYY" is replaced with the suffix from the analysis file. Thus selection of the file "ANALYSIS.A1A" to analyze mission file "M2" produces the BTS file named "BTSM2.A1A", which is shown in Table A6. Appendix D provides a collection of the BTS data files produced on this project. Each table is the result of analyzing a specified mission with a specified analysis file.

Each BTS table displays movies of the mission variables specified by the BQs. Each row is associated with a particular BQ. The first two columns contain BQ parameters consisting of the lower and upper limits for a TRUE BQ answer. Column 3 identifies the co/t letter designation. Column 4 identifies the BQ type. Column 5 gives the row number which is also used as the BQ number - the number that corresponds to the BQ in the associated ANALYSIS file. That BQ number is repeated at the far right of the table. Between the BQ numbers is the plot of the BQ answers, displaying a "T" when the BQ parameter conditions are met, otherwise a blank or a presentation aid symbols are displayed. BQ answers for successive time samples are plotted horizontally across the row. Time sample numbers are given over and below the BQ answers. Although the table may appear difficult at first, the analyst can soon develop a facility to directly read and interpret the BTS tables.

Table A6 File: BTSM2.A1A

```
 LOWER   UPPER  CO/T BQ    ROW
 BOUND   BOUND       TYPE   #            Time --------->
                                 000000000111111111122222222
                                 123456789012345678901234567
-20000   -9000   A    1     1  TTT-|----|----|----|----|--  1
 -9000   -8000   A    1     2  ---T|----|----|----|----|--  2
 -8000   -7000   A    1     3  ----TT---|----|----|----|--  3
 -7000   -6000   A    1     4  ----|----|----|----|----|--  4
 -6000   -5000   A    1     5  ----|----|----|----|----|--  5
 -5000   -4000   A    1     6  ----|-T--|----|----|----|--  6   Distance to objective
 -4000   -3000   A    1     7  ----|--T-|----|----|----|--  7
 -3000   -2000   A    1     8  ----|----|----|----|----|--  8
 -2000   -1000   A    1     9  ----|---T|----|----|----|--  9
 -1000       0   A    1    10  ----|----T----|----|----|-- 10
     0    1000   A    1    11  ----|----|----|----|----|-- 11
  1000   20000   A    1    12  ----|----|TTTTTTTTTTTTTTTTT 12

    -1       5   A    2    13  TTT-|----|----|TTTTTTTTTT-T 13
     5      10   A    2    14  ----T----|----T----|----|T- 14
    10      20   A    2    15  ----|T-TTT-TT-|----|----|-- 15
    20      30   A    2    16  ----|-T--|T--T|----|----|-- 16   Velocity
    30      40   A    2    17  ---T|----|----|----|----|-- 17
    40      50   A    2    18  ----|----|----|----|----|-- 18
    50      60   A    2    19  ----|----|----|----|----|-- 19

    -1     100   A    3    20  ----|----|----|----|----|-- 20
   100     200   A    3    21  TTT-T----|----|----|----|-- 21
   200     300   A    3    22  ----|----|----|----|----|-- 22
   300     400   A    3    23  ----|T---|----|----|----|-- 23
   400     500   A    3    24  ----|-T--|----|----|----|-- 24   Dispersion
   500    1000   A    3    25  ---T|--T-|----|----|----|-- 25
  1000    1500   A    3    26  ----|---T|----|----|----|-- 26
  1500    2000   A    3    27  ----|----TT---|----|----|-- 27
  2000    2500   A    3    28  ----|----|-TTTTTTTTTTTTTTTT 28
  2500   20000   A    3    29  ----|----|----|----|----|-- 29

-20000   -2500   A    4    30  ----|----|----|----|----|-- 30
 -2500   -2000   A    4    31  ----|----|----|----|----|-- 31
* -2000  -1500   A    4    32  ----|----|----|----|----|-- 32
 -1500   -1000   A    4    33  ----|----|----|----|----|-- 33
 -1000    -500   A    4    34  ---T|TTTT|----|----|----|-- 34
  -500       0   A    4    35  TTT-T----|----|----|----|-- 35   Relative position
     0    1000   A    4    36  ----|----|T---|----|----|-- 36   of leader
  1000    1500   A    4    37  ----|----T----|----|----|-- 37
  1500    2000   A    4    38  ----|----|----|----|----|-- 38
  2000    2500   A    4    39  ----|----|----|----|----|-- 39
  2500   20000   A    4    40  ----|----|-TTTTTTTTTTTTTTTT 40

                                 000000000111111111122222222
                                 123456789012345678901234567
```

Appendix B

Automated Data Analyzer

Mission Files

Three missions were analyzed for this project. Their mission files are listed in the following table. Interpretation of the mission files and definitions of the terms used are given in Appendix A under the section titled **Preliminary Mission Analysis**.

Table B1 File: Mission M2

```
 6
1
13
 A
A60
A11
A12
A13
A14
A21
A22
A23
A24
A31
A32
A33
A34
2
13
 B
B60
B11
B12
B13
B14
B21
B22
B23
B24
B31
B32
B33
B34
3
13
 C
60C
10C
11C
12C
13C
20C
21C
22C
23C
D21
D22
D23
D24
4
13
 D
D60
D11
D12
D13
D14
D31
D32
D33
D34
30C
31C
32C
33C
5
1
E
H60
6
1
F
H50
3200,9000,3200,9500,2800,9000,3625,9000
D12B24
```

Table B2 File: Mission M4

```
6
1
9
A
66A
21A
22A
31A
32A
C31
C32
C33
C34
2
9
B
66B
11B
12B
21B
22B
D31
D32
D33
D34
3
10
C
C66
C65
C11
C12
C13
C14
C21
C22
C23
C24
4
12
D
D66
D65
D11
D12
D13
D14
D21
D22
D23
D24
31B
32B
5
1
E
H66
6
1
F
H65
5100,10000,5100,10500,4700,10000,5675,10280
D33D11
```

Table B3 File: Mission M7

```
6
1
9
A
66A
11A
13A
26A
21A
23A
36A
31A
33A
2
9
B
66C
11C
13C
36C
31C
D31
D32
D33
D34
3
13
C
C66
C65
C11
C12
C13
C14
C21
C22
C23
C24
C31
C33
C34
4
11
D
D66
D65
D12
D13
D14
D21
D22
D23
D24
26C
21C
5
1
E
H66
6
1
F
H65
5500,12400,5500,12600,5100,12600,5750,12400
C1211C
```

Appendix C

Automated Data Analyzer

Analysis Files

An analysis file specifies and documents the analysis to be run. Several types of analysis files have been developed, each identified by its 3 character suffix (.XXX) attached to the file name "ANALYSIS". A description of each type, identified by its suffix, is given in the following:

.A1A

This analysis file specifies an analysis of co/team A. The analysis uses BQ types 1, 2, 3, and 4 to analyze:

1. Distance of the co/team to the objective,
2. Co/team velocity,
3. Co/team dispersion,
4. Distance from co/team to team leader.

.A1B,.A1C,.A1D

These analysis files are identical the .A1A file except for the co/team letter designation changed.

.TFA

This analysis file uses BQ types 1, 7, 8,and 9 to display, in a single file, the distance to the objective of the 4 co/teams. Combining the 4 co/team data to one file helps to compare co/team performances. BQ types 7, 8, and 9 are used to analyze "co/team J" (co/team J refers to the TF), length, distance to objective, and dispersion, respectively.

.C1W, .D1W

BQ types 1 and 6 are used in this analysis to calculate the distance to the objective of the lead co/team (used to identify how close the TF is to the objective point), and distance between the lead co/team and the other co/teams, as well as the TF commander. Note that the designation for the TF commander is "E". The two analyses differ only in the specification of co/team C or D as the lead element.

These analyses specify sets of BQs with a broad range of BQ parameters, extending from -20,000 to +20,000 meters from the objective. That range is assigned to multiple BQs with non-overlapping range parameters so that the variables being tested (lead co/team range to objective, relative distances from co/teams to the lead co/team, and the distance from the TF commander and the lead co/team) will always be in one BQ parameter range. Consequently, the answer to one BQ of a set will be TRUE and the variable can be "tracked" through out the mission. This information supports design of another analysis to test an hypothesis.

.C1V AND .D1V

Like the analysis described above, these differ only in that co/teams C or D are specified as the lead co/team. These analyses were designed after study of the results obtained with the .C1W and .D1W shown above to test two hypotheses.

Interpreting the Analysis File

Analyses are defined by the analysis file which specifies the BQVs to be used, the parameters used to form the BQ, and the co/team the BQ is to be applied to. As shown in Table C1, the file consists of specifications arranged in rows, each of which specifies an individual BQ. Up to 60 BQ can be specified in the file. Each row consists of 6 data entries, some of which may not be used for a particular analysis, and therefore, may be blank. Columns 1 and 2 provide an index number for each row i.e., each BQ. Next, two sets of 7 columns define the lower and upper (upper bound is exclusive) bounds, respectively, for the BQ answer to be true. For instance, in row 1, the lower bound is -20000 while the upper bound is -4000 (meters). If the BQV is within those bounds, the BQ answer "T" is output.

Next, two columns identify co/team letter designations. The first of these columns is used only when the last column is a "6" which specifies calculation of the relative distance between two co/teams. Thus, in that case, these two columns indicate the two co/teams involved. For instance, in Table C6, row 7 specifies that the distance between co/teams C and A is to be computed and if the result is greater than (more positive) than -20000 meters and less than or equal to -6000 meters, the BQ answer is TRUE.

This distance calculation is typically applied to the co/teams defined for the mission; however, the calculation device can also be used for other purposes. An artificial co/team can be defined as any individual or group desired. We defined a "co/team" to be the TF commander, designated as "co/team E". The TF executive officer is designated as "co/team F". In this way the distance between these officers and other TF elements can be tested during the mission. In the Table C6, rows 22 through 26 specify such BQs.

The last 2 columns of the analysis file specify the BQ to be used in the analysis. Note that while this file consists of 60 rows, each row actually specifies the BQ for the 60 columns of the BTS file. Thus, it is convenient to mentally or physically rotate the this file 90 degrees so row 1 is on the left. Then, the rotated rows become columns which correspond to the columns of the BTS file. Please note that the table name at the top of the page and the page number is <u>not</u> part of the data file.

Table C1 File: ANALYSIS.A1A

1	-20000	-9000	A	1
2	-9000	-8000	A	1
3	-8000	-7000	A	1
4	-7000	-6000	A	1
5	-6000	-5000	A	1
6	-5000	-4000	A	1
7	-4000	-3000	A	1
8	-3000	-2000	A	1
9	-2000	-1000	A	1
10	-1000	0	A	1
11	0	1000	A	1
12	1000	20000	A	1
13	-1	5	A	2
14	5	10	A	2
15	10	20	A	2
16	20	30	A	2
17	30	40	A	2
18	40	50	A	2
19	50	60	A	2
20	-1	100	A	3
21	100	200	A	3
22	200	300	A	3
23	300	400	A	3
24	400	500	A	3
25	500	1000	A	3
26	1000	1500	A	3
27	1500	2000	A	3
28	2000	2500	A	3
29	2500	20000	A	3
30	-20000	-2500	A	4
31	-2500	-2000	A	4
32	-2000	-1500	A	4
33	-1500	-1000	A	4
34	-1000	-500	A	4
35	-500	0	A	4
36	0	1000	A	4
37	1000	1500	A	4
38	1500	2000	A	4
39	2000	2500	A	4
40	2500	20000	A	4
41	0	0	J	0
42	0	0	J	0
43	0	0	J	0
44	0	0	J	0
45	0	0	J	0
46	0	0	J	0
47	0	0	J	0
48	0	0	J	0
49	0	0	J	0
50	0	0	J	0
51	0	0	J	0
52	0	0	J	0
53	0	0	J	0
54	0	0	J	0
55	0	0	J	0
56	0	0	J	0
57	0	0	J	0
58	0	0	J	0
59	0	0	J	0
60	0	0	J	0

Table C2   File: ANALYSIS.A1B

1	-20000	-9000	B	1
2	-9000	-8000	B	1
3	-8000	-7000	B	1
4	-7000	-6000	B	1
5	-6000	-5000	B	1
6	-5000	-4000	B	1
7	-4000	-3000	B	1
8	-3000	-2000	B	1
9	-2000	-1000	B	1
10	-1000	0	B	1
11	0	1000	B	1
12	1000	20000	B	1
13	-1	5	B	2
14	5	10	B	2
15	10	20	B	2
16	20	30	B	2
17	30	40	B	2
18	40	50	B	2
19	50	60	B	2
20	-1	100	B	3
21	100	200	B	3
22	200	300	B	3
23	300	400	B	3
24	400	500	B	3
25	500	1000	B	3
26	1000	1500	B	3
27	1500	2000	B	3
28	2000	2500	B	3
29	2500	20000	B	3
30	-20000	-2500	B	4
31	-2500	-2000	B	4
32	-2000	-1500	B	4
33	-1500	-1000	B	4
34	-1000	-500	B	4
35	-500	0	B	4
36	0	1000	B	4
37	1000	1500	B	4
38	1500	2000	B	4
39	2000	2500	B	4
40	2500	20000	B	4
41	0	0	J	0
42	0	0	J	0
43	0	0	J	0
44	0	0	J	0
45	0	0	J	0
46	0	0	J	0
47	0	0	J	0
48	0	0	J	0
49	0	0	J	0
50	0	0	J	0
51	0	0	J	0
52	0	0	J	0
53	0	0	J	0
54	0	0	J	0
55	0	0	J	0
56	0	0	J	0
57	0	0	J	0
58	0	0	J	0
59	0	0	J	0
60	0	0	J	0

Table C3 File: ANALYSIS.A1C

1	-20000	-9000	C	1
2	-9000	-8000	C	1
3	-8000	-7000	C	1
4	-7000	-6000	C	1
5	-6000	-5000	C	1
6	-5000	-4000	C	1
7	-4000	-3000	C	1
8	-3000	-2000	C	1
9	-2000	-1000	C	1
10	-1000	0	C	1
11	0	1000	C	1
12	1000	20000	C	1
13	-1	5	C	2
14	5	10	C	2
15	10	20	C	2
16	20	30	C	2
17	30	40	C	2
18	40	50	C	2
19	50	60	C	2
20	-1	100	C	3
21	100	200	C	3
22	200	300	C	3
23	300	400	C	3
24	400	500	C	3
25	500	1000	C	3
26	1000	1500	C	3
27	1500	2000	C	3
28	2000	2500	C	3
29	2500	20000	C	3
30	-20000	-2500	C	4
31	-2500	-2000	C	4
32	-2000	-1500	C	4
33	-1500	-1000	C	4
34	-1000	-500	C	4
35	-500	0	C	4
36	0	1000	C	4
37	1000	1500	C	4
38	1500	2000	C	4
39	2000	2500	C	4
40	2500	20000	C	4
41	0	0	J	0
42	0	0	J	0
43	0	0	J	0
44	0	0	J	0
45	0	0	J	0
46	0	0	J	0
47	0	0	J	0
48	0	0	J	0
49	0	0	J	0
50	0	0	J	0
51	0	0	J	0
52	0	0	J	0
53	0	0	J	0
54	0	0	J	0
55	0	0	J	0
56	0	0	J	0
57	0	0	J	0
58	0	0	J	0
59	0	0	J	0
60	0	0	J	0

Table C4 File: ANALYSIS.A1D

1	-20000	-9000	D	1
2	-9000	-8000	D	1
3	-8000	-7000	D	1
4	-7000	-6000	D	1
5	-6000	-5000	D	1
6	-5000	-4000	D	1
7	-4000	-3000	D	1
8	-3000	-2000	D	1
9	-2000	-1000	D	1
10	-1000	0	D	1
11	0	1000	D	1
12	1000	20000	D	1
13	-1	5	D	2
14	5	10	D	2
15	10	20	D	2
16	20	30	D	2
17	30	40	D	2
18	40	50	D	2
19	50	60	D	2
20	-1	100	D	3
21	100	200	D	3
22	200	300	D	3
23	300	400	D	3
24	400	500	D	3
25	500	1000	D	3
26	1000	1500	D	3
27	1500	2000	D	3
28	2000	2500	D	3
29	2500	20000	D	3
30	-20000	-2500	D	4
31	-2500	-2000	D	4
32	-2000	-1500	D	4
33	-1500	-1000	D	4
34	-1000	-500	D	4
35	-500	0	D	4
36	0	1000	D	4
37	1000	1500	D	4
38	1500	2000	D	4
39	2000	2500	D	4
40	2500	20000	D	4
41	0	0	J	0
42	0	0	J	0
43	0	0	J	0
44	0	0	J	0
45	0	0	J	0
46	0	0	J	0
47	0	0	J	0
48	0	0	J	0
49	0	0	J	0
50	0	0	J	0
51	0	0	J	0
52	0	0	J	0
53	0	0	J	0
54	0	0	J	0
55	0	0	J	0
56	0	0	J	0
57	0	0	J	0
58	0	0	J	0
59	0	0	J	0
60	0	0	J	0

Table C5 File: ANALYSIS.TFA

1	-20000	-7000	A	1
2	-7000	-6000	A	1
3	-6000	-5000	A	1
4	-5000	-4000	A	1
5	-4000	-3000	A	1
6	-3000	-2000	A	1
7	-2000	-1000	A	1
8	-1000	0	A	1
9	0	1000	A	1
10	1000	20000	A	1
11	-20000	-7000	B	1
12	-7000	-6000	B	1
13	-6000	-5000	B	1
14	-5000	-4000	B	1
15	-4000	-3000	B	1
16	-3000	-2000	B	1
17	-2000	-1000	B	1
18	-1000	0	B	1
19	0	1000	B	1
20	1000	20000	B	1
21	-20000	-7000	C	1
22	-7000	-6000	C	1
23	-6000	-5000	C	1
24	-5000	-4000	C	1
25	-4000	-3000	C	1
26	-3000	-2000	C	1
27	-2000	-1000	C	1
28	-1000	0	C	1
29	0	1000	C	1
30	1000	20000	C	1
31	-20000	-7000	D	1
32	-7000	-6000	D	1
33	-6000	-5000	D	1
34	-5000	-4000	D	1
35	-4000	-3000	D	1
36	-3000	-2000	D	1
37	-2000	-1000	D	1
38	-1000	0	D	1
39	0	1000	D	1
40	1000	20000	D	1
41	0	3000	J	7
42	3000	4000	J	7
43	4000	6000	J	7
44	6000	8000	J	7
45	8000	20000	J	7
46	-20000	-10000	J	8
47	-10000	-8000	J	8
48	-8000	-6000	J	8
49	-6000	-4000	J	8
50	-4000	-2000	J	8
51	-2000	-1000	J	8
52	-1000	-500	J	8
53	-500	0	J	8
54	0	500	J	8
55	500	20000	J	8
56	-10000	-5000	J	9
57	-5000	-2000	J	9
58	-2000	2000	J	9
59	2000	5000	J	9
60	5000	10000	J	9

Table C6 File: ANALYSIS.C1W

1	-20000	-6000	C	1
2	-6000	-4000	C	1
3	-4000	-2000	C	1
4	-2000	-1000	C	1
5	-1000	0	C	1
6	0	20000	C	1
7	-20000	-6000	CA	6
8	-6000	-4000	CA	6
9	-4000	-2000	CA	6
10	-2000	-1000	CA	6
11	-1000	20000	CA	6
12	-20000	-6000	CB	6
13	-6000	-4000	CB	6
14	-4000	-2000	CB	6
15	-2000	-1000	CB	6
16	-1000	20000	CB	6
17	-20000	-6000	CD	6
18	-6000	-4000	CD	6
19	-4000	-2000	CD	6
20	-2000	-1000	CD	6
21	-1000	20000	CD	6
22	-20000	-6000	CE	6
23	-6000	-4000	CE	6
24	-4000	-2000	CE	6
25	-2000	-1000	CE	6
26	-1000	20000	CE	6
27	0	0	J	0
28	0	0	J	0
29	0	0	J	0
30	0	0	J	0
31	0	0	J	0
32	0	0	J	0
33	0	0	J	0
34	0	0	J	0
35	0	0	J	0
36	0	0	J	0
37	0	0	J	0
38	0	0	J	0
39	0	0	J	0
40	0	0	J	0
41	0	0	J	0
42	0	0	J	0
43	0	0	J	0
44	0	0	J	0
45	0	0	J	0
46	0	0	J	0
47	0	0	J	0
48	0	0	J	0
49	0	0	J	0
50	0	0	J	0
51	0	0	J	0
52	0	0	J	0
53	0	0	J	0
54	0	0	J	0
55	0	0	J	0
56	0	0	J	0
57	0	0	J	0
58	0	0	J	0
59	0	0	J	0
60	0	0	J	0

Table C7 File: ANALYSIS.D1W

1	-20000	-6000	D	1
2	-6000	-4000	D	1
3	-4000	-2000	D	1
4	-2000	-1000	D	1
5	-1000	0	D	1
6	0	20000	D	1
7	-20000	-6000	DA	6
8	-6000	-4000	DA	6
9	-4000	-2000	DA	6
10	-2000	-1000	DA	6
11	-1000	20000	DA	6
12	-20000	-6000	DB	6
13	-6000	-4000	DB	6
14	-4000	-2000	DB	6
15	-2000	-1000	DB	6
16	-1000	20000	DB	6
17	-20000	-6000	DC	6
18	-6000	-4000	DC	6
19	-4000	-2000	DC	6
20	-2000	-1000	DC	6
21	-1000	20000	DC	6
22	-20000	-6000	DE	6
23	-6000	-4000	DE	6
24	-4000	-2000	DE	6
25	-2000	-1000	DE	6
26	-1000	20000	DE	6
27	0	0	J	0
28	0	0	J	0
29	0	0	J	0
30	0	0	J	0
31	0	0	J	0
32	0	0	J	0
33	0	0	J	0
34	0	0	J	0
35	0	0	J	0
36	0	0	J	0
37	0	0	J	0
38	0	0	J	0
39	0	0	J	0
40	0	0	J	0
41	0	0	J	0
42	0	0	J	0
43	0	0	J	0
44	0	0	J	0
45	0	0	J	0
46	0	0	J	0
47	0	0	J	0
48	0	0	J	0
49	0	0	J	0
50	0	0	J	0
51	0	0	J	0
52	0	0	J	0
53	0	0	J	0
54	0	0	J	0
55	0	0	J	0
56	0	0	J	0
57	0	0	J	0
58	0	0	J	0
59	0	0	J	0
60	0	0	J	0

Table C8 File: ANALYSIS.C1V

1	-20000	-4000	C	1
2	-4000	-2000	C	1
3	-2000	0	C	1
4	-2000	2000	CA	6
5	-2000	2000	CB	6
6	-2000	2000	CD	6
7	-2000	2000	CE	6
8	0	0	J	0
9	0	0	J	0
10	0	0	J	0
11	0	0	J	0
12	0	0	J	0
13	0	0	J	0
14	0	0	J	0
15	0	0	J	0
16	0	0	J	0
17	0	0	J	0
18	0	0	J	0
19	0	0	J	0
20	0	0	J	0
21	0	0	J	0
22	0	0	J	0
23	0	0	J	0
24	0	0	J	0
25	0	0	J	0
26	0	0	J	0
27	0	0	J	0
28	0	0	J	0
29	0	0	J	0
30	0	0	J	0
31	0	0	J	0
32	0	0	J	0
33	0	0	J	0
34	0	0	J	0
35	0	0	J	0
36	0	0	J	0
37	0	0	J	0
38	0	0	J	0
39	0	0	J	0
40	0	0	J	0
41	0	0	J	0
42	0	0	J	0
43	0	0	J	0
44	0	0	J	0
45	0	0	J	0
46	0	0	J	0
47	0	0	J	0
48	0	0	J	0
49	0	0	J	0
50	0	0	J	0
51	0	0	J	0
52	0	0	J	0
53	0	0	J	0
54	0	0	J	0
55	0	0	J	0
56	0	0	J	0
57	0	0	J	0
58	0	0	J	0
59	0	0	J	0
60	0	0	J	0

Table C9 File: ANALYSIS.D1V

1	-20000	-4000	D	1
2	-4000	-2000	D	1
3	-2000	0	D	1
4	-2000	2000	DA	6
5	-2000	2000	DB	6
6	-2000	2000	DC	6
7	-2000	2000	DE	6
8	0	0	J	0
9	0	0	J	0
10	0	0	J	0
11	0	0	J	0
12	0	0	J	0
13	0	0	J	0
14	0	0	J	0
15	0	0	J	0
16	0	0	J	0
17	0	0	J	0
18	0	0	J	0
19	0	0	J	0
20	0	0	J	0
21	0	0	J	0
22	0	0	J	0
23	0	0	J	0
24	0	0	J	0
25	0	0	J	0
26	0	0	J	0
27	0	0	J	0
28	0	0	J	0
29	0	0	J	0
30	0	0	J	0
31	0	0	J	0
32	0	0	J	0
33	0	0	J	0
34	0	0	J	0
35	0	0	J	0
36	0	0	J	0
37	0	0	J	0
38	0	0	J	0
39	0	0	J	0
40	0	0	J	0
41	0	0	J	0
42	0	0	J	0
43	0	0	J	0
44	0	0	J	0
45	0	0	J	0
46	0	0	J	0
47	0	0	J	0
48	0	0	J	0
49	0	0	J	0
50	0	0	J	0
51	0	0	J	0
52	0	0	J	0
53	0	0	J	0
54	0	0	J	0
55	0	0	J	0
56	0	0	J	0
57	0	0	J	0
58	0	0	J	0
59	0	0	J	0
60	0	0	J	0

Appendix D

Automated Data Analyzer

BTS Files

BTS files are produced by the ADA processor. BTS data files are viewed by analysts to better understand the dynamics and relationships of mission variables and are also read by the analysis programs to detect patterns relevant to mission effectiveness.

BTS data files are named as "BTSMX.YYY", where the "X" is replaced with the mission identification number "YYY" is replaced with the suffix from the analysis file. Thus, selection of the file "ANALYSIS.A1A" to analyze mission file "M2" produces the BTS file named "BTSM2.A1A". The tables in this appendix are the BTSs developed for this project. Each table is the result of analyzing a specified mission with a specified analysis file.

A description of the BTS files is given in Appendix A in the section titled "File: BTS".

TABLE D1 BTSM2.A1A

```
LOWER   UPPER  CO/T BQ    ROW
BOUND   BOUND       TYPE  #          Time ------->
                                000000000111111111122222222
                                123456789012345678901234567
-20000  -9000   A    1     1    TTT-|----|----|----|----|--   1
 -9000  -8000   A    1     2    ---T|----|----|----|----|--   2
 -8000  -7000   A    1     3    ----TT---|----|----|----|--   3
 -7000  -6000   A    1     4    ----|----|----|----|----|--   4
 -6000  -5000   A    1     5    ----|----|----|----|----|--   5
 -5000  -4000   A    1     6    ----|-T--|----|----|----|--   6
 -4000  -3000   A    1     7    ----|--T-|----|----|----|--   7
 -3000  -2000   A    1     8    ----|----|----|----|----|--   8
 -2000  -1000   A    1     9    ----|---T|----|----|----|--   9
 -1000      0   A    1    10    ----|----T----|----|----|--  10
     0   1000   A    1    11    ----|----|----|----|----|--  11
  1000  20000   A    1    12    ----|----|TTTTTTTTTTTTTTTTT  12

    -1      5   A    2    13    TTT-|----|----|TTTTTTTTTT-T  13
     5     10   A    2    14    ----T----|----T----|----|T-  14
    10     20   A    2    15    ----|T-TTT-TT-|----|----|--  15
    20     30   A    2    16    ----|-T--|T--T|----|----|--  16
    30     40   A    2    17    ---T|----|----|----|----|--  17
    40     50   A    2    18    ----|----|----|----|----|--  18
    50     60   A    2    19    ----|----|----|----|----|--  19

    -1    100   A    3    20    ----|----|----|----|----|--  20
   100    200   A    3    21    TTT-T----|----|----|----|--  21
   200    300   A    3    22    ----|----|----|----|----|--  22
   300    400   A    3    23    ----|T---|----|----|----|--  23
   400    500   A    3    24    ----|-T--|----|----|----|--  24
   500   1000   A    3    25    ---T|--T-|----|----|----|--  25
  1000   1500   A    3    26    ----|---T|----|----|----|--  26
  1500   2000   A    3    27    ----|----TT---|----|----|--  27
  2000   2500   A    3    28    ----|----|-TTTTTTTTTTTTTTTT  28
  2500  20000   A    3    29    ----|----|----|----|----|--  29

-20000  -2500   A    4    30    ----|----|----|----|----|--  30
 -2500  -2000   A    4    31    ----|----|----|----|----|--  31
 -2000  -1500   A    4    32    ----|----|----|----|----|--  32
 -1500  -1000   A    4    33    ----|----|----|----|----|--  33
 -1000   -500   A    4    34    ---T|TTTT|----|----|----|--  34
  -500      0   A    4    35    TTT-T----|----|----|----|--  35
     0   1000   A    4    36    ----|----|T---|----|----|--  36
  1000   1500   A    4    37    ----|----T----|----|----|--  37
  1500   2000   A    4    38    ----|----|----|----|----|--  38
  2000   2500   A    4    39    ----|----|----|----|----|--  39
  2500  20000   A    4    40    ----|----|-TTTTTTTTTTTTTTTT  40

     0      0   J    0    41                                 41
     0      0   J    0    42                                 42
     0      0   J    0    43                                 43
     0      0   J    0    44                                 44
     0      0   J    0    45                                 45
     0      0   J    0    46                                 46
     0      0   J    0    47                                 47
     0      0   J    0    48                                 48
     0      0   J    0    49                                 49
     0      0   J    0    50                                 50
     0      0   J    0    51                                 51
     0      0   J    0    52                                 52
     0      0   J    0    53                                 53
     0      0   J    0    54                                 54
     0      0   J    0    55                                 55
     0      0   J    0    56                                 56
     0      0   J    0    57                                 57
     0      0   J    0    58                                 58
     0      0   J    0    59                                 59
     0      0   J    0    60                                 60
                                000000000111111111122222222
                                123456789012345678901234567
```

TABLE D2 BTSM2.A1B

```
 LOWER    UPPER  CO/T  BQ    ROW
 BOUND    BOUND        TYPE   #          Time ------->
                                  000000000111111111122222222
                                  123456789012345678901234567
-20000    -9000   B     1      1  TTTTTT----|-----|-----|-----|--   1
 -9000    -8000   B     1      2  -----|-T---|-----|-----|-----|--  2
 -8000    -7000   B     1      3  -----|--T--|-----|-----|-----|--  3
 -7000    -6000   B     1      4  -----|-----|-----|-----|-----|--  4
 -6000    -5000   B     1      5  -----|----T|-----|-----|-----|--  5
 -5000    -4000   B     1      6  -----|-----T-----|-----|-----|--  6
 -4000    -3000   B     1      7  -----|-----|T----|-----|-----|--  7
 -3000    -2000   B     1      8  -----|-----|-----|-----|-----|--  8
 -2000    -1000   B     1      9  -----|-----|-T---|-----|-----|--  9
 -1000        0   B     1     10  -----|-----|-----|-----|-----|-- 10
     0     1000   B     1     11  -----|-----|---T-|-----|-----|-- 11
  1000    20000   B     1     12  -----|-----|---TTTTTTTTTTTTTT 12

    -1        5   B     2     13  TTTTT-----|-----TTTTTTTTTTTTT 13
     5       10   B     2     14  -----|-TT--|-----|-----|-----|-- 14
    10       20   B     2     15  -----|T----|T-TT-|-----|-----|-- 15
    20       30   B     2     16  -----|---TT-T----|-----|-----|-- 16
    30       40   B     2     17  -----|-----|-----|-----|-----|-- 17
    40       50   B     2     18  -----|-----|-----|-----|-----|-- 18
    50       60   B     2     19  -----|-----|-----|-----|-----|-- 19

    -1      100   B     3     20  TT---|-----|-----|-----|-----|-- 20
   100      200   B     3     21  --TTT-T---|-----T-TTTTTTTTT-- 21
   200      300   B     3     22  -----|--TTT-T-T|T----|-----|TT 22
   300      400   B     3     23  -----|-----|-----|-----|-----|-- 23
   400      500   B     3     24  -----|-----|-----|-----|-----|-- 24
   500     1000   B     3     25  -----|T----|T-T--|-----|-----|-- 25
  1000     1500   B     3     26  -----|-----|-----|-----|-----|-- 26
  1500     2000   B     3     27  -----|-----|-----|-----|-----|-- 27
  2000     2500   B     3     28  -----|-----|-----|-----|-----|-- 28
  2500    20000   B     3     29  -----|-----|-----|-----|-----|-- 29

-20000    -2500   B     4     30  -----|-----|-----|-----|-----|-- 30
 -2500    -2000   B     4     31  -----|-----|-----|-----|-----|-- 31
 -2000    -1500   B     4     32  -----|-----|-----|-----|-----|-- 32
 -1500    -1000   B     4     33  -----|T----|---TT|-----|-----|-- 33
 -1000     -500   B     4     34  -----|---TT|TT--TTTTTTTTTTTTT 34
  -500        0   B     4     35  -T-TT-T---|-----|-----|-----|-- 35
     0     1000   B     4     36  T-T--|-----T-----|-----|-----|-- 36
  1000     1500   B     4     37  -----|-----|-----|-----|-----|-- 37
  1500     2000   B     4     38  -----|-----|-----|-----|-----|-- 38
  2000     2500   B     4     39  -----|-----|-----|-----|-----|-- 39
  2500    20000   B     4     40  -----|-----|-----|-----|-----|-- 40

     0        0   J     0     41                                   41
     0        0   J     0     42                                   42
     0        0   J     0     43                                   43
     0        0   J     0     44                                   44
     0        0   J     0     45                                   45
     0        0   J     0     46                                   46
     0        0   J     0     47                                   47
     0        0   J     0     48                                   48
     0        0   J     0     49                                   49
     0        0   J     0     50                                   50
     0        0   J     0     51                                   51
     0        0   J     0     52                                   52
     0        0   J     0     53                                   53
     0        0   J     0     54                                   54
     0        0   J     0     55                                   55
     0        0   J     0     56                                   56
     0        0   J     0     57                                   57
     0        0   J     0     58                                   58
     0        0   J     0     59                                   59
     0        0   J     0     60                                   60
                                  000000000111111111122222222
                                  123456789012345678901234567
```

TABLE D3 BTSM2.A1C

```
 LOWER    UPPER  CO/T BQ     ROW
 BOUND    BOUND       TYPE    #          Time ------>
                                   000000000111111111122222222
                                   123456789012345678901234567
-20000    -9000   C    1      1    TTT-|----|----|----|----|--    1
 -9000    -8000   C    1      2    ---T|----|----|----|----|--    2
 -8000    -7000   C    1      3    ----|----|----|----|----|--    3
 -7000    -6000   C    1      4    ----T----|----|----|----|--    4
 -6000    -5000   C    1      5    ----|----|----|----|----|--    5
 -5000    -4000   C    1      6    ----|T---|----|----|----|--    6
 -4000    -3000   C    1      7    ----|-T--|----|----|----|--    7
 -3000    -2000   C    1      8    ----|----|----|----|----|--    8
 -2000    -1000   C    1      9    ----|--T-|----|----|----|--    9
 -1000        0   C    1     10    ----|----|----|----|----|--   10
     0     1000   C    1     11    ----|---T|----|----|----|--   11
  1000    20000   C    1     12    ----|----TTTTTTTTTTTTTTTTTT   12

    -1        5   C    2     13    TTT-|----|----|-TT-TTTTTTTT   13
     5       10   C    2     14    ----|----|----|T--T|----|--   14
    10       20   C    2     15    ----|TT--|-TTTT----|----|--   15
    20       30   C    2     16    ---TT--TTTT---|----|----|--   16
    30       40   C    2     17    ----|----|----|----|----|--   17
    40       50   C    2     18    ----|----|----|----|----|--   18
    50       60   C    2     19    ----|----|----|----|----|--   19

    -1      100   C    3     20    ----T----|----|----|----|--   20
   100      200   C    3     21    ----|TT-T|----|----|----|--   21
   200      300   C    3     22    ----|----|----|----|----|--   22
   300      400   C    3     23    ----|----T----|----|----|--   23
   400      500   C    3     24    TT--|----|----|----|----|--   24
   500     1000   C    3     25    --T-|--T-|T---|----|----|--   25
  1000     1500   C    3     26    ---T|----|-T--|----|----|--   26
  1500     2000   C    3     27    ----|----|--T-|----|----|--   27
  2000     2500   C    3     28    ----|----|----|----|----|--   28
  2500    20000   C    3     29    ----|----|---TTTTTTTTTTTTTT   29

-20000    -2500   C    4     30    ----|----|--TTTTTTTTTTTTTTT   30
 -2500    -2000   C    4     31    ----|----|-T--|----|----|--   31
 -2000    -1500   C    4     32    --T-|----|----|----|----|--   32
 -1500    -1000   C    4     33    ----|----|T---|----|----|--   33
 -1000     -500   C    4     34    TT-T|--T-T----|----|----|--   34
  -500        0   C    4     35    ----T-T--|----|----|----|--   35
     0     1000   C    4     36    ----|T--T|----|----|----|--   36
  1000     1500   C    4     37    ----|----|----|----|----|--   37
  1500     2000   C    4     38    ----|----|----|----|----|--   38
  2000     2500   C    4     39    ----|----|----|----|----|--   39
  2500    20000   C    4     40    ----|----|----|----|----|--   40

     0        0   J    0     41                                  41
     0        0   J    0     42                                  42
     0        0   J    0     43                                  43
     0        0   J    0     44                                  44
     0        0   J    0     45                                  45
     0        0   J    0     46                                  46
     0        0   J    0     47                                  47
     0        0   J    0     48                                  48
     0        0   J    0     49                                  49
     0        0   J    0     50                                  50
     0        0   J    0     51                                  51
     0        0   J    0     52                                  52
     0        0   J    0     53                                  53
     0        0   J    0     54                                  54
     0        0   J    0     55                                  55
     0        0   J    0     56                                  56
     0        0   J    0     57                                  57
     0        0   J    0     58                                  58
     0        0   J    0     59                                  59
     0        0   J    0     60                                  60
                                   000000000111111111122222222
                                   123456789012345678901234567
```

TABLE D4 BTSM2.A1D

```
 LOWER    UPPER  CO/T BQ     ROW
 BOUND    BOUND       TYPE    #          Time ------->
                                  000000000111111111122222222
                                  123456789012345678901234567
-20000   -9000    D     1     1  TT--|----|----|----|----|--   1
 -9000   -8000    D     1     2  --T-|----|----|----|----|--   2
 -8000   -7000    D     1     3  ----|----|----|----|----|--   3
 -7000   -6000    D     1     4  ---T|----|----|----|----|--   4
 -6000   -5000    D     1     5  ----T----|----|----|----|--   5
 -5000   -4000    D     1     6  ----|----|----|----|----|--   6
 -4000   -3000    D     1     7  ----|T---|----|----|----|--   7
 -3000   -2000    D     1     8  ----|-T--|----|----|----|--   8
 -2000   -1000    D     1     9  ----|--T-|----|----|----|--   9
 -1000       0    D     1    10  ----|---T|----|----|----|--  10
     0    1000    D     1    11  ----|----|----|----|----|--  11
  1000   20000    D     1    12  ----|----TTTTTTTTTTTTTTTTTT  12

    -1       5    D     2    13  TT--|----|--TTTTT-TTTTTTTTT  13
     5      10    D     2    14  ----|----|----|----|----|--  14
    10      20    D     2    15  ---TTTTTTTTT--|--T-|----|--  15
    20      30    D     2    16  ----|----|----|----|----|--  16
    30      40    D     2    17  ----|----|----|----|----|--  17
    40      50    D     2    18  ----|----|----|----|----|--  18
    50      60    D     2    19  --T-|----|----|----|----|--  19

    -1     100    D     3    20  ---T|--T-|----|----|----|--  20
   100     200    D     3    21  --T-T-T--|----|----|----|--  21
   200     300    D     3    22  ----|T---|----|----|----|--  22
   300     400    D     3    23  ----|----|----|----|----|--  23
   400     500    D     3    24  ----|----|----|----|----|--  24
   500    1000    D     3    25  ----|---T|----|----|----|--  25
  1000    1500    D     3    26  ----|----T----|----|----|--  26
  1500    2000    D     3    27  TT--|----|T---|----|----|--  27
  2000    2500    D     3    28  ----|----|-TTTTTT--|----|--  28
  2500   20000    D     3    29  ----|----|----|--TTTTTTTTTT  29

-20000   -2500    D     4    30  ----|----|----|----|----|--  30
 -2500   -2000    D     4    31  ----|--T-|----|----|----|--  31
 -2000   -1500    D     4    32  ----|---T|----|----|----|--  32
 -1500   -1000    D     4    33  ----|-T--T----|----|----|--  33
 -1000    -500    D     4    34  ----|T---|----|----|----|--  34
  -500       0    D     4    35  --TTT----|----|----|----|--  35
     0    1000    D     4    36  ----|----|----|----|----|--  36
  1000    1500    D     4    37  TT--|----|----|----|----|--  37
  1500    2000    D     4    38  ----|----|T---|----|----|--  38
  2000    2500    D     4    39  ----|----|----|----|----|--  39
  2500   20000    D     4    40  ----|----|-TTTTTTTTTTTTTTTT  40

     0       0    J     0    41                               41
     0       0    J     0    42                               42
     0       0    J     0    43                               43
     0       0    J     0    44                               44
     0       0    J     0    45                               45
     0       0    J     0    46                               46
     0       0    J     0    47                               47
     0       0    J     0    48                               48
     0       0    J     0    49                               49
     0       0    J     0    50                               50
     0       0    J     0    51                               51
     0       0    J     0    52                               52
     0       0    J     0    53                               53
     0       0    J     0    54                               54
     0       0    J     0    55                               55
     0       0    J     0    56                               56
     0       0    J     0    57                               57
     0       0    J     0    58                               58
     0       0    J     0    59                               59
     0       0    J     0    60                               60
                                  000000000111111111122222222
                                  123456789012345678901234567
```

TABLE D5 BTSM2.TFA

LOWER BOUND	UPPER BOUND	CO/T	BQ TYPE	ROW #	Time ------>	
					000000000111111111122222222	
					123456789012345678901234567	
-20000	-7000	A	1	1	TTTTTT---|----|----|----|--	1
-7000	-6000	A	1	2	----|----|----|----|----|--	2
-6000	-5000	A	1	3	----|----|----|----|----|--	3
-5000	-4000	A	1	4	----|-T--|----|----|----|--	4
-4000	-3000	A	1	5	----|--T-|----|----|----|--	5
-3000	-2000	A	1	6	----|----|----|----|----|--	6
-2000	-1000	A	1	7	----|---T|----|----|----|--	7
-1000	0	A	1	8	----|----T----|----|----|--	8
0	1000	A	1	9	----|----|----|----|----|--	9
1000	20000	A	1	10	----|----|TTTTTTTTTTTTTTTTT	10
-20000	-7000	B	1	11	TTTTTTTT-|----|----|----|--	11
-7000	-6000	B	1	12	----|----|----|----|----|--	12
-6000	-5000	B	1	13	----|---T|----|----|----|--	13
-5000	-4000	B	1	14	----|----T----|----|----|--	14
-4000	-3000	B	1	15	----|----|T---|----|----|--	15
-3000	-2000	B	1	16	----|----|----|----|----|--	16
-2000	-1000	B	1	17	----|----|-T--|----|----|--	17
-1000	0	B	1	18	----|----|----|----|----|--	18
0	1000	B	1	19	----|----|--T-|----|----|--	19
1000	20000	B	1	20	----|----|---TTTTTTTTTTTTTT	20
-20000	-7000	C	1	21	TTTT|----|----|----|----|--	21
-7000	-6000	C	1	22	----T----|----|----|----|--	22
-6000	-5000	C	1	23	----|----|----|----|----|--	23
-5000	-4000	C	1	24	----|T---|----|----|----|--	24
-4000	-3000	C	1	25	----|-T--|----|----|----|--	25
-3000	-2000	C	1	26	----|----|----|----|----|--	26
-2000	-1000	C	1	27	----|--T-|----|----|----|--	27
-1000	0	C	1	28	----|----|----|----|----|--	28
0	1000	C	1	29	----|---T|----|----|----|--	29
1000	20000	C	1	30	----|----TTTTTTTTTTTTTTTTTT	30
-20000	-7000	D	1	31	TTT-|----|----|----|----|--	31
-7000	-6000	D	1	32	---T|----|----|----|----|--	32
-6000	-5000	D	1	33	----T----|----|----|----|--	33
-5000	-4000	D	1	34	----|----|----|----|----|--	34
-4000	-3000	D	1	35	----|T---|----|----|----|--	35
-3000	-2000	D	1	36	----|-T--|----|----|----|--	36
-2000	-1000	D	1	37	----|--T-|----|----|----|--	37
-1000	0	D	1	38	----|---T|----|----|----|--	38
0	1000	D	1	39	----|----|----|----|----|--	39
1000	20000	D	1	40	----|----TTTTTTTTTTTTTTTTTT	40
0	3000	J	7	41	-TT-|----|----|----|----|--	41
3000	4000	J	7	42	----|----|----|----|----|--	42
4000	6000	J	7	43	---TTT---|----|----|----|--	43
6000	8000	J	7	44	----|-TTTT----|----|----|--	44
8000	20000	J	7	45	----|----|TTTTTTTTTTTTTTTTT	45
-20000	-10000	J	8	46	-T--|----|----|----|----|--	46
-10000	-8000	J	8	47	----|----|----|----|----|--	47
-8000	-6000	J	8	48	--TT|----|----|----|----|--	48
-6000	-4000	J	8	49	----T----|----|----|----|--	49
-4000	-2000	J	8	50	----|T---|----|----|----|--	50
-2000	-1000	J	8	51	----|-T--|----|----|----|--	51
-1000	-500	J	8	52	----|----|----|----|----|--	52
-500	0	J	8	53	T---|----|----|----|----|--	53
0	500	J	8	54	----|--T-|----|----|----|--	54
500	20000	J	8	55	----|---TTTTTTTTTTTTTTTTTTT	55
-10000	-5000	J	9	56	----|----|---T|--T-T---TT-T	56
-5000	-2000	J	9	57	----|-TTTTTTT-|----|----|--	57
-2000	2000	J	9	58	T-TTTT---|----|---T|-T--|T-	58
2000	5000	J	9	59	-T--|----|----|-T--|T-T-|--	59
5000	10000	J	9	60	----|----|----TT---|----|--	60
					000000000111111111122222222	
					123456789012345678901234567	

TABLE D6 BTSM2.D1W

```
 LOWER   UPPER  CO/T  BQ    ROW
 BOUND   BOUND        TYPE   #         Time ------>
                                  000000000111111111122222222
                                  123456789012345678901234567
-20000   -6000   D     1     1    TTTT|----|----|----|----|--   1
 -6000   -4000   D     1     2    ----T----|----|----|----|--   2
 -4000   -2000   D     1     3    ----|TT--|----|----|----|--   3
 -2000   -1000   D     1     4    ----|--T-|----|----|----|--   4
 -1000       0   D     1     5    ----|---T|----|----|----|--   5
     0   20000   D     1     6    ----|----TTTTTTTTTTTTTTTTTT   6

-20000   -6000   DA    6     7    ----|----|----|----|----|--   7
 -6000   -4000   DA    6     8    ----|----|----|----|----|--   8
 -4000   -2000   DA    6     9    --T-TTT--|----|----|----|--   9
 -2000   -1000   DA    6    10    ---T|--TTTTTT-|----|----|--  10
 -1000   20000   DA    6    11    TT--|----|---TTTTTTTTTTTTTT  11

-20000   -6000   DB    6    12    ----|----|----|----|----|--  12
 -6000   -4000   DB    6    13    ---TTTTTTTTTTT|TTTTTTTTTTTT  13
 -4000   -2000   DB    6    14    --T-|----|----T----|----|--  14
 -2000   -1000   DB    6    15    ----|----|----|----|----|--  15
 -1000   20000   DB    6    16    TT--|----|----|----|----|--  16

-20000   -6000   DC    6    17    ----|----|----|----|----|--  17
 -6000   -4000   DC    6    18    ----|----|----|----|----|--  18
 -4000   -2000   DC    6    19    --TT|----|----|----|----|--  19
 -2000   -1000   DC    6    20    ----TT---|----|----|----|--  20
 -1000   20000   DC    6    21    TT--|-TTTTTTTTTTTTTTTTTTTTT  21

-20000   -6000   DE    6    22    ----TTTTTTTTTTTTTTTTTTTTTTT  22
 -6000   -4000   DE    6    23    ---T|----|----|----|----|--  23
 -4000   -2000   DE    6    24    TTT-|----|----|----|----|--  24
 -2000   -1000   DE    6    25    ----|----|----|----|----|--  25
 -1000   20000   DE    6    26    ----|----|----|----|----|--  26

     0       0   J     0    27                                 27
     0       0   J     0    28                                 28
     0       0   J     0    29                                 29
     0       0   J     0    30                                 30
     0       0   J     0    31                                 31
     0       0   J     0    32                                 32
     0       0   J     0    33                                 33
     0       0   J     0    34                                 34
     0       0   J     0    35                                 35
     0       0   J     0    36                                 36
     0       0   J     0    37                                 37
     0       0   J     0    38                                 38
     0       0   J     0    39                                 39
     0       0   J     0    40                                 40
     0       0   J     0    41                                 41
     0       0   J     0    42                                 42
     0       0   J     0    43                                 43
     0       0   J     0    44                                 44
     0       0   J     0    45                                 45
     0       0   J     0    46                                 46
     0       0   J     0    47                                 47
     0       0   J     0    48                                 48
     0       0   J     0    49                                 49
     0       0   J     0    50                                 50
     0       0   J     0    51                                 51
     0       0   J     0    52                                 52
     0       0   J     0    53                                 53
     0       0   J     0    54                                 54
     0       0   J     0    55                                 55
     0       0   J     0    56                                 56
     0       0   J     0    57                                 57
     0       0   J     0    58                                 58
     0       0   J     0    59                                 59
     0       0   J     0    60                                 60
                                  000000000111111111122222222
                                  123456789012345678901234567
```

TABLE D7 BTSM2.D1V

```
LOWER   UPPER  CO/T BQ   ROW
BOUND   BOUND       TYPE  #           Time ------>
                                000000000111111111122222222
                                123456789012345678901234567
-20000  -4000   D    1     1    TTTTT----|----|----|----|--   1
 -4000  -2000   D    1     2    ----|TT--|----|----|----|--   2
 -2000      0   D    1     3    ----|--TT|----|----|----|--   3

 -2000   2000   DA   6     4    TT-T|--TTTTTTTTTTTTTTTTTTTT   4

 -2000   2000   DB   6     5    TT--|----|----|----|----|--   5

 -2000   2000   DC   6     6    ----TTTTTT----|----|----|--   6

 -2000   2000   DE   6     7    ----|----|----|----|----|--   7

     0      0   J    0     8                                  8
     0      0   J    0     9                                  9
     0      0   J    0    10                                 10
     0      0   J    0    11                                 11
     0      0   J    0    12                                 12
     0      0   J    0    13                                 13
     0      0   J    0    14                                 14
     0      0   J    0    15                                 15
     0      0   J    0    16                                 16
     0      0   J    0    17                                 17
     0      0   J    0    18                                 18
     0      0   J    0    19                                 19
     0      0   J    0    20                                 20
     0      0   J    0    21                                 21
     0      0   J    0    22                                 22
     0      0   J    0    23                                 23
     0      0   J    0    24                                 24
     0      0   J    0    25                                 25
     0      0   J    0    26                                 26
     0      0   J    0    27                                 27
     0      0   J    0    28                                 28
     0      0   J    0    29                                 29
     0      0   J    0    30                                 30
     0      0   J    0    31                                 31
     0      0   J    0    32                                 32
     0      0   J    0    33                                 33
     0      0   J    0    34                                 34
     0      0   J    0    35                                 35
     0      0   J    0    36                                 36
     0      0   J    0    37                                 37
     0      0   J    0    38                                 38
     0      0   J    0    39                                 39
     0      0   J    0    40                                 40
     0      0   J    0    41                                 41
     0      0   J    0    42                                 42
     0      0   J    0    43                                 43
     0      0   J    0    44                                 44
     0      0   J    0    45                                 45
     0      0   J    0    46                                 46
     0      0   J    0    47                                 47
     0      0   J    0    48                                 48
     0      0   J    0    49                                 49
     0      0   J    0    50                                 50
     0      0   J    0    51                                 51
     0      0   J    0    52                                 52
     0      0   J    0    53                                 53
     0      0   J    0    54                                 54
     0      0   J    0    55                                 55
     0      0   J    0    56                                 56
     0      0   J    0    57                                 57
     0      0   J    0    58                                 58
     0      0   J    0    59                                 59
     0      0   J    0    60                                 60
                                000000000111111111122222222
                                123456789012345678901234567
```

TABLE D8 BTSM4.A1A

```
 LOWER    UPPER  CO/T  BQ    ROW
 BOUND    BOUND        TYPE   #           Time ------>
                                  0000000001111111111222222222233333333334444
                                  1234567890123456789012345678901234567890123
-20000    -9000   A     1     1   TTTTTTTTT|----|----|----|----|----|----|---   1
 -9000    -8000   A     1     2   ----|----TT---|----|----|----|----|----|---   2
 -8000    -7000   A     1     3   ----|----|-TT-|----|----|----|----|----|---   3
 -7000    -6000   A     1     4   ----|----|---T|----|----|----|----|----|---   4
 -6000    -5000   A     1     5   ----|----|----T----|----|----|----|----|---   5
 -5000    -4000   A     1     6   ----|----|----|T---|----|----|----|----|---   6
 -4000    -3000   A     1     7   ----|----|----|-T--|----|----|----|----|---   7
 -3000    -2000   A     1     8   ----|----|----|--T-|----|----|----|----|---   8
 -2000    -1000   A     1     9   ----|----|----|---TTT---|----|----|----|---   9
 -1000        0   A     1    10   ----|----|----|----|-TTTTTTTTTTTTTTTTTTTTTT  10
     0     1000   A     1    11   ----|----|----|----|----|----|----|----|---  11
  1000    20000   A     1    12   ----|----|----|----|----|----|----|----|---  12

    -1        5   A     2    13   T---|----T----|----T-TTTTTTTTTTTTTTTTTTTTTT  13
     5       10   A     2    14   ----TT-T-|-TTTT----|T---|----|----|----|---  14
    10       20   A     2    15   ----|-T-T|T---|TTTT|----|----|----|----|---  15
    20       30   A     2    16   -TTT|----|----|----|----|----|----|----|---  16
    30       40   A     2    17   ----|----|----|----|----|----|----|----|---  17
    40       50   A     2    18   ----|----|----|----|----|----|----|----|---  18
    50       60   A     2    19   ----|----|----|----|----|----|----|----|---  19

    -1      100   A     3    20   ----|----|----|----|----|----|----|----|---  20
   100      200   A     3    21   ----|----|----|----|----|----|----|----|TTT  21
   200      300   A     3    22   ----|----|----|----|----|----|T-TTTTTTTT---  22
   300      400   A     3    23   ----|----|----|----TTTTTTTT--T-T--|----|---  23
   400      500   A     3    24   T---|----|T---|---T|----|--TT|----|----|---  24
   500     1000   A     3    25   -T--TTTTTT-TTTTTTT-|----|----|----|----|---  25
  1000     1500   A     3    26   --TT|----|----|----|----|----|----|----|---  26
  1500     2000   A     3    27   ----|----|----|----|----|----|----|----|---  27
  2000     2500   A     3    28   ----|----|----|----|----|----|----|----|---  28
  2500    20000   A     3    29   ----|----|----|----|----|----|----|----|---  29

-20000    -2500   A     4    30   ----|----|----|----|----|----|----|----|---  30
 -2500    -2000   A     4    31   -TT-|----|----|----|----|----|----|----|---  31
 -2000    -1500   A     4    32   ----|----|----|----|----|----|----|----|---  32
 -1500    -1000   A     4    33   ---T|----|----|----|----|----|----|----|---  33
 -1000     -500   A     4    34   T---T----|----|T---|----|--T-|--T-|T-TTTT--  34
  -500        0   A     4    35   ----|TTTTTTTTTT-T-TTTT--|----|-T--T-T--|-TT  35
     0     1000   A     4    36   ----|----|----|--T-|--TTTTT-TTT--T|----|---  36
  1000     1500   A     4    37   ----|----|----|----|----|----|----|----|---  37
  1500     2000   A     4    38   ----|----|----|----|----|----|----|----|---  38
  2000     2500   A     4    39   ----|----|----|----|----|----|----|----|---  39
  2500    20000   A     4    40   ----|----|----|----|----|----|----|----|---  40

     0        0   J     0    41                                                41
     0        0   J     0    42                                                42
     0        0   J     0    43                                                43
     0        0   J     0    44                                                44
     0        0   J     0    45                                                45
     0        0   J     0    46                                                46
     0        0   J     0    47                                                47
     0        0   J     0    48                                                48
     0        0   J     0    49                                                49
     0        0   J     0    50                                                50
     0        0   J     0    51                                                51
     0        0   J     0    52                                                52
     0        0   J     0    53                                                53
     0        0   J     0    54                                                54
     0        0   J     0    55                                                55
     0        0   J     0    56                                                56
     0        0   J     0    57                                                57
     0        0   J     0    58                                                58
     0        0   J     0    59                                                59
     0        0   J     0    60                                                60
                                  0000000001111111111222222222233333333334444
                                  1234567890123456789012345678901234567890123
```

TABLE D9 BTSM4.A1B

```
 LOWER   UPPER  CO/T BQ    ROW
 BOUND   BOUND       TYPE   #          Time ------>
                                 0000000001111111111222222222233333333334444
                                 1234567890123456789012345678901234567890123
-20000   -9000   B    1      1   TTT-|----|----|----|----|----|----|----|---   1
 -9000   -8000   B    1      2   ---T|----|----|----|----|----|----|----|---   2
 -8000   -7000   B    1      3   ----T----|----|----|----|----|----|----|---   3
 -7000   -6000   B    1      4   ----|----|----|----|----|----|----|----|---   4
 -6000   -5000   B    1      5   ----|T---|----|----|----|----|----|----|---   5
 -5000   -4000   B    1      6   ----|----|----|----|----|----|----|----|---   6
 -4000   -3000   B    1      7   ----|-T--|----|----|----|----|----|----|---   7
 -3000   -2000   B    1      8   ----|----|----|----|----|----|----|----|---   8
 -2000   -1000   B    1      9   ----|--TTT----|----|----|----|----|----|---   9
 -1000       0   B    1     10   ----|----|TTTTTTTTTTTTTTTTTT-T----|----|--T  10
     0    1000   B    1     11   ----|----|----|----|----|---T|TTTTTTTTTTTT-  11
  1000   20000   B    1     12   ----|----|----|----|----|----|----|----|---  12

    -1       5   B    2     13   T---|----T-TTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTT  13
     5      10   B    2     14   ----|----|T---|----|----|----|----|----|---  14
    10      20   B    2     15   --T-TT--T|----|----|----|----|----|----|---  15
    20      30   B    2     16   ---T|-TT-|----|----|----|----|----|----|---  16
    30      40   B    2     17   ----|----|----|----|----|----|----|----|---  17
    40      50   B    2     18   -T--|----|----|----|----|----|----|----|---  18
    50      60   B    2     19   ----|----|----|----|----|----|----|----|---  19

    -1     100   B    3     20   ----|----|----|----|----|---T|TTTTTTTTTTTTT  20
   100     200   B    3     21   T---|----|TT-TTTTTTTTTTTTTTT-T----|----|---  21
   200     300   B    3     22   -TTT|---T|--T-|----|----|----|----|----|---  22
   300     400   B    3     23   ----T----|----|----|----|----|----|----|---  23
   400     500   B    3     24   ----|--T-|----|----|----|----|----|----|---  24
   500    1000   B    3     25   ----|TT--T----|----|----|----|----|----|---  25
  1000    1500   B    3     26   ----|----|----|----|----|----|----|----|---  26
  1500    2000   B    3     27   ----|----|----|----|----|----|----|----|---  27
  2000    2500   B    3     28   ----|----|----|----|----|----|----|----|---  28
  2500   20000   B    3     29   ----|----|----|----|----|----|----|----|---  29

-20000   -2500   B    4     30   T---|----|----|----|----|----|----|----|---  30
 -2500   -2000   B    4     31   ----|----|----|----|----|----|----|----|---  31
 -2000   -1500   B    4     32   ----|----|----|----|----|----|----|----|---  32
 -1500   -1000   B    4     33   ----|----|----|----|----|----|----|----|---  33
 -1000    -500   B    4     34   ----|----|----|----|----|----|----|----|---  34
  -500       0   B    4     35   ----|----|----|----|----|----|----|----|---  35
     0    1000   B    4     36   ----|----|----|----|----|----|----|----|---  36
  1000    1500   B    4     37   -T--|----|----|----|----|----|----|----|---  37
  1500    2000   B    4     38   ----|----|----|----|----|----|----|----|---  38
  2000    2500   B    4     39   ----|----|----|----|----|----|----|----|---  39
  2500   20000   B    4     40   --TTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTT  40

     0       0   J    0     41                                                41
     0       0   J    0     42                                                42
     0       0   J    0     43                                                43
     0       0   J    0     44                                                44
     0       0   J    0     45                                                45
     0       0   J    0     46                                                46
     0       0   J    0     47                                                47
     0       0   J    0     48                                                48
     0       0   J    0     49                                                49
     0       0   J    0     50                                                50
     0       0   J    0     51                                                51
     0       0   J    0     52                                                52
     0       0   J    0     53                                                53
     0       0   J    0     54                                                54
     0       0   J    0     55                                                55
     0       0   J    0     56                                                56
     0       0   J    0     57                                                57
     0       0   J    0     58                                                58
     0       0   J    0     59                                                59
     0       0   J    0     60                                                60
                                 0000000001111111111222222222233333333334444
                                 1234567890123456789012345678901234567890123
```

TABLE D10 BTSM4.A1C

```
LOWER   UPPER  CO/T BQ    ROW
BOUND   BOUND       TYPE   #          Time ------>
                               0000000001111111111222222222233333333334444
                               1234567890123456789012345678901234567890123
-20000  -9000   C    1     1   TTT-|----|----|----|----|----|----|----|---  1
 -9000  -8000   C    1     2   ---T|----|----|----|----|----|----|----|---  2
 -8000  -7000   C    1     3   ----TTT--|----|----|----|----|----|----|---  3
 -7000  -6000   C    1     4   ----|--TT|----|----|----|----|----|----|---  4
 -6000  -5000   C    1     5   ----|----T----|----|----|----|----|----|---  5
 -5000  -4000   C    1     6   ----|----|TTT-|----|----|----|----|----|---  6
 -4000  -3000   C    1     7   ----|----|---T|----|----|----|----|----|---  7
 -3000  -2000   C    1     8   ----|----|----TTTTTTTTT-|----|----|----|---  8
 -2000  -1000   C    1     9   ----|----|----|----|---TTTTTTTTTTTTTTTTTTTT  9
 -1000      0   C    1    10   ----|----|----|----|----|----|----|----|--- 10
     0   1000   C    1    11   ----|----|----|----|----|----|----|----|--- 11
  1000  20000   C    1    12   ----|----|----|----|----|----|----|----|--- 12

    -1      5   C    2    13   T---|---T|-T--|TTTTTTTTTTTTTTTTTTTTTTTTTTTT 13
     5     10   C    2    14   ----|-T--TT-T-T----|----|----|----|----|--- 14
    10     20   C    2    15   --TTTT-T-|---T|----|----|----|----|----|--- 15
    20     30   C    2    16   ----|----|----|----|----|----|----|----|--- 16
    30     40   C    2    17   ----|----|----|----|----|----|----|----|--- 17
    40     50   C    2    18   ----|----|----|----|----|----|----|----|--- 18
    50     60   C    2    19   -T--|----|----|----|----|----|----|----|--- 19

    -1    100   C    3    20   ----|----|----|----|----|----|----|----|--- 20
   100    200   C    3    21   --TTTT-TT|----|----|----|----|----|----|--- 21
   200    300   C    3    22   ----|-T--TTT--|----|----|----|----|----|--- 22
   300    400   C    3    23   ----|----|----|----|----|----|----|----|--- 23
   400    500   C    3    24   -T--|----|----|----|----|----|----|----|--- 24
   500   1000   C    3    25   T---|----|--TT|----|----|----|----|----|--- 25
  1000   1500   C    3    26   ----|----|----TTTTTTTTTTTTTTTTTTTTTTTTTTTTT 26
  1500   2000   C    3    27   ----|----|----|----|----|----|----|----|--- 27
  2000   2500   C    3    28   ----|----|----|----|----|----|----|----|--- 28
  2500  20000   C    3    29   ----|----|----|----|----|----|----|----|--- 29

-20000  -2500   C    4    30   ----|----|----|----|----|----|----|----|--- 30
 -2500  -2000   C    4    31   ----|----|----|----|----|----|----|----|--- 31
 -2000  -1500   C    4    32   ----|----|----|----|----|----|----|----|--- 32
 -1500  -1000   C    4    33   ----|----|----|----|----TTTTTTTTTTTTTTTTTTT 33
 -1000   -500   C    4    34   T---|--TT|----|----|----|----|----|----|--- 34
  -500      0   C    4    35   -TTTT----|----|----|----|----|----|----|--- 35
     0   1000   C    4    36   ----|TT--|----|----|T-T-|----|----|----|--- 36
  1000   1500   C    4    37   ----|----TT---|-TT-T-T-T|----|----|----|--- 37
  1500   2000   C    4    38   ----|----|-TT-|---T|----|----|----|----|--- 38
  2000   2500   C    4    39   ----|----|----|----|----|----|----|----|--- 39
  2500  20000   C    4    40   ----|----|---TTT---|----|----|----|----|--- 40

     0      0   J    0    41                                               41
     0      0   J    0    42                                               42
     0      0   J    0    43                                               43
     0      0   J    0    44                                               44
     0      0   J    0    45                                               45
     0      0   J    0    46                                               46
     0      0   J    0    47                                               47
     0      0   J    0    48                                               48
     0      0   J    0    49                                               49
     0      0   J    0    50                                               50
     0      0   J    0    51                                               51
     0      0   J    0    52                                               52
     0      0   J    0    53                                               53
     0      0   J    0    54                                               54
     0      0   J    0    55                                               55
     0      0   J    0    56                                               56
     0      0   J    0    57                                               57
     0      0   J    0    58                                               58
     0      0   J    0    59                                               59
     0      0   J    0    60                                               60
                               0000000001111111111222222222233333333334444
                               1234567890123456789012345678901234567890123
```

TABLE D11   BTSM4.A1D

```
 LOWER   UPPER  CO/T BQ    ROW
 BOUND   BOUND       TYPE   #           Time ------>
                                0000000001111111111222222222233333333334444
                                1234567890123456789012345678901234567890123
-20000   -9000   D    1     1   TTTTTT---|----|----|----|----|----|----|---  1
 -9000   -8000   D    1     2   ----|-TTTT----|----|----|----|----|----|---  2
 -8000   -7000   D    1     3   ----|----|TTT-|----|----|----|----|----|---  3
 -7000   -6000   D    1     4   ----|----|---TT----|----|----|----|----|---  4
 -6000   -5000   D    1     5   ----|----|----|TTT-|----|----|----|----|---  5
 -5000   -4000   D    1     6   ----|----|----|----|----|----|----|----|---  6
 -4000   -3000   D    1     7   ----|----|----|---T|----|----|----|----|---  7
 -3000   -2000   D    1     8   ----|----|----|----T----|----|----|----|---  8
 -2000   -1000   D    1     9   ----|----|----|----|TT--|----|----|----|---  9
 -1000       0   D    1    10   ----|----|----|----|--TT|----|----|----|--- 10
     0    1000   D    1    11   ----|----|----|----|----TTTTTT----|----|--- 11
  1000   20000   D    1    12   ----|----|----|----|----|----|TTTTTTTTTTTTT 12

    -1       5   D    2    13   T---|----|TT--|----|-T--TTTTTT--T-TTTTTTT-- 13
     5      10   D    2    14   ----|----|--T-TTTT-|T-TT|----|-T-T|----|--- 14
    10      20   D    2    15   ----TTTTTT---T|---T|----|----|T---|----|-TT 15
    20      30   D    2    16   --TT|----|----|----T----|----|----|----|--- 16
    30      40   D    2    17   -T--|----|----|----|----|----|----|----|--- 17
    40      50   D    2    18   ----|----|----|----|----|----|----|----|--- 18
    50      60   D    2    19   ----|----|----|----|----|----|----|----|--- 19

    -1     100   D    3    20   T---|----|T--T|T---TTTTT|---TT----|----|--- 20
   100     200   D    3    21   ---TTTT--|----T-TT-|----TTTT-|----|----|--- 21
   200     300   D    3    22   ----|--T-T--T-|---T|----|----|----|----|--- 22
   300     400   D    3    23   -T--|----|-T--|----|----|----|----|----|--- 23
   400     500   D    3    24   ----|---T|----|----|----|----|T---|----|--- 24
   500    1000   D    3    25   ----|----|----|----|----|----|-TTT|TTTTTTT- 25
  1000    1500   D    3    26   --T-|----|----|----|----|----|----T----|--T 26
  1500    2000   D    3    27   ----|----|----|----|----|----|----|----|--- 27
  2000    2500   D    3    28   ----|----|----|----|----|----|----|----|--- 28
  2500   20000   D    3    29   ----|----|----|----|----|----|----|----|--- 29

-20000   -2500   D    4    30   TT--|----|----|----|----|----|----|----|--- 30
 -2500   -2000   D    4    31   --T-|----|----|----|----|----|----|----|--- 31
 -2000   -1500   D    4    32   ----|----|----|----|----|----|----|----|--- 32
 -1500   -1000   D    4    33   ----T----|----|----|----|----|----|----|--- 33
 -1000    -500   D    4    34   ---T|----|----|----|----|----|----|----|--- 34
  -500       0   D    4    35   ----|----|----|----|----|----|----|----|--- 35
     0    1000   D    4    36   ----|----|----|----|----|----|----|----|--- 36
  1000    1500   D    4    37   ----|----|----|----|----|----|----|----|--- 37
  1500    2000   D    4    38   ----|----|----|----|----|----|----|----|--- 38
  2000    2500   D    4    39   ----|T---|----|----|----|----|----|----|--- 39
  2500   20000   D    4    40   ----|-TTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTT 40

     0       0   J    0    41                                               41
     0       0   J    0    42                                               42
     0       0   J    0    43                                               43
     0       0   J    0    44                                               44
     0       0   J    0    45                                               45
     0       0   J    0    46                                               46
     0       0   J    0    47                                               47
     0       0   J    0    48                                               48
     0       0   J    0    49                                               49
     0       0   J    0    50                                               50
     0       0   J    0    51                                               51
     0       0   J    0    52                                               52
     0       0   J    0    53                                               53
     0       0   J    0    54                                               54
     0       0   J    0    55                                               55
     0       0   J    0    56                                               56
     0       0   J    0    57                                               57
     0       0   J    0    58                                               58
     0       0   J    0    59                                               59
     0       0   J    0    60                                               60
                                0000000001111111111222222222233333333334444
                                1234567890123456789012345678901234567890123
```

TABLE D12   BTSM4.TFA

```
LOWER   UPPER  CO/T BQ    ROW
BOUND   BOUND       TYPE   #          Time ------>
                                0000000001111111111222222222233333333334444
                                1234567890123456789012345678901234567890123
-20000   -7000   A   1     1    TTTTTTTTTTTTT-|----|----|----|----|----|---  1
 -7000   -6000   A   1     2    ----|----|---T|----|----|----|----|----|---  2
 -6000   -5000   A   1     3    ----|----|----T----|----|----|----|----|---  3
 -5000   -4000   A   1     4    ----|----|----|T---|----|----|----|----|---  4
 -4000   -3000   A   1     5    ----|----|----|-T--|----|----|----|----|---  5
 -3000   -2000   A   1     6    ----|----|----|--T-|----|----|----|----|---  6
 -2000   -1000   A   1     7    ----|----|----|---TTT---|----|----|----|---  7
 -1000       0   A   1     8    ----|----|----|----|-TTTTTTTTTTTTTTTTTTTTTT  8
     0    1000   A   1     9    ----|----|----|----|----|----|----|----|---  9
  1000   20000   A   1    10    ----|----|----|----|----|----|----|----|--- 10

-20000   -7000   B   1    11    TTTTT----|----|----|----|----|----|----|--- 11
 -7000   -6000   B   1    12    ----|----|----|----|----|----|----|----|--- 12
 -6000   -5000   B   1    13    ----|T---|----|----|----|----|----|----|--- 13
 -5000   -4000   B   1    14    ----|----|----|----|----|----|----|----|--- 14
 -4000   -3000   B   1    15    ----|-T--|----|----|----|----|----|----|--- 15
 -3000   -2000   B   1    16    ----|----|----|----|----|----|----|----|--- 16
 -2000   -1000   B   1    17    ----|--TTT----|----|----|----|----|----|--- 17
 -1000       0   B   1    18    ----|----|TTTTTTTTTTTTTTTTTT-T----|----|--T 18
     0    1000   B   1    19    ----|----|----|----|----|---T|TTTTTTTTTTTT- 19
  1000   20000   B   1    20    ----|----|----|----|----|----|----|----|--- 20

-20000   -7000   C   1    21    TTTTTTT--|----|----|----|----|----|----|--- 21
 -7000   -6000   C   1    22    ----|--TT|----|----|----|----|----|----|--- 22
 -6000   -5000   C   1    23    ----|----T----|----|----|----|----|----|--- 23
 -5000   -4000   C   1    24    ----|----|TTT-|----|----|----|----|----|--- 24
 -4000   -3000   C   1    25    ----|----|---T|----|----|----|----|----|--- 25
 -3000   -2000   C   1    26    ----|----|----TTTTTTTTT-|----|----|----|--- 26
 -2000   -1000   C   1    27    ----|----|----|----|---TTTTTTTTTTTTTTTTTTTT 27
 -1000       0   C   1    28    ----|----|----|----|----|----|----|----|--- 28
     0    1000   C   1    29    ----|----|----|----|----|----|----|----|--- 29
  1000   20000   C   1    30    ----|----|----|----|----|----|----|----|--- 30

-20000   -7000   D   1    31    TTTTTTTTTTTTT-|----|----|----|----|----|--- 31
 -7000   -6000   D   1    32    ----|----|---TT----|----|----|----|----|--- 32
 -6000   -5000   D   1    33    ----|----|----|TTT-|----|----|----|----|--- 33
 -5000   -4000   D   1    34    ----|----|----|----|----|----|----|----|--- 34
 -4000   -3000   D   1    35    ----|----|----|---T|----|----|----|----|--- 35
 -3000   -2000   D   1    36    ----|----|----|----T----|----|----|----|--- 36
 -2000   -1000   D   1    37    ----|----|----|----|TT--|----|----|----|--- 37
 -1000       0   D   1    38    ----|----|----|----|--TT|----|----|----|--- 38
     0    1000   D   1    39    ----|----|----|----|----TTTTTT----|----|--- 39
  1000   20000   D   1    40    ----|----|----|----|----|----|TTTTTTTTTTTTT 40

     0    3000   J   7    41    ----|----|----|----TTTTTTTTTTTTTTTTTTTTTTTT 41
  3000    4000   J   7    42    ----|----|----|---T|----|----|----|----|--- 42
  4000    6000   J   7    43    --TTT----|----|TTT-|----|----|----|----|--- 43
  6000    8000   J   7    44    -T--|TTTTTTTTTT----|----|----|----|----|--- 44
  8000   20000   J   7    45    ----|----|----|----|----|----|----|----|--- 45

-20000  -10000   J   8    46    -T--|----|----|----|----|----|----|----|--- 46
-10000   -8000   J   8    47    --T-|----|----|----|----|----|----|----|--- 47
 -8000   -6000   J   8    48    ---T|----|----|----|----|----|----|----|--- 48
 -6000   -4000   J   8    49    ----T----|----|----|----|----|----|----|--- 49
 -4000   -2000   J   8    50    ----|T---|----|----|----|----|----|----|--- 50
 -2000   -1000   J   8    51    ----|-T--|----|----|----|----|----|----|--- 51
 -1000    -500   J   8    52    ----|----|----|----|----|----|----|----|--- 52
  -500       0   J   8    53    T---|--TTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTT 53
     0     500   J   8    54    ----|----|----|----|----|----|----|----|--- 54
   500   20000   J   8    55    ----|----|----|----|----|----|----|----|--- 55

-10000   -5000   J   9    56    ----|----|-T--|----|----|----|----|----|--- 56
 -5000   -2000   J   9    57    ----|--T-|--TTTTTT-|----|----|----|----|--- 57
 -2000    2000   J   9    58    TTT-TTT--|----|---TTTTTTTTTTTTTTTTTTTTTTTTT 58
  2000    5000   J   9    59    ---T|----|----|----|----|----|----|----|--- 59
  5000   10000   J   9    60    ----|---TTT---|----|----|----|----|----|--- 60
                                0000000001111111111222222222233333333334444
                                1234567890123456789012345678901234567890123
```

TABLE D13 BTSM4.D1W

```
 LOWER     UPPER  CO/T  BQ     ROW
 BOUND     BOUND        TYPE    #           Time ------>
                                  0000000001111111111222222222233333333334444
                                  1234567890123456789012345678901234567890123
-20000     -6000   D     1      1 TTTTTTTTTTTTTTT----|----|----|----|----|---  1
 -6000     -4000   D     1      2 ----|----|----|TTT-|----|----|----|----|---  2
 -4000     -2000   D     1      3 ----|----|----|---TT----|----|----|----|---  3
 -2000     -1000   D     1      4 ----|----|----|----|TT--|----|----|----|---  4
 -1000         0   D     1      5 ----|----|----|----|--TT|----|----|----|---  5
     0     20000   D     1      6 ----|----|----|----|----TTTTTTTTTTTTTTTTTTT  6

-20000     -6000   DA    6      7 ----|----|----|----|----|----|----|----|---  7
 -6000     -4000   DA    6      8 ----|----|----|----|----|----|----|----|---  8
 -4000     -2000   DA    6      9 ----|TTT-|----|----|----|----|-TTTTTTTTTTTT  9
 -2000     -1000   DA    6     10 -T-TT----|----|----|----|--TT|T---|----|--- 10
 -1000     20000   DA    6     11 T-T-|---TTTTTTTTTTTTTTTTTTT--T----|----|--- 11

-20000     -6000   DB    6     12 ----|----|----|----|----|----|----|----|--- 12
 -6000     -4000   DB    6     13 ----|----|----|----|----|----|----|----|--- 13
 -4000     -2000   DB    6     14 ----|----|----|----|----|----|--TTTTTTTTTT- 14
 -2000     -1000   DB    6     15 ----|----|----|----|----|----|TT--|----|--T 15
 -1000     20000   DB    6     16 TTTTTTTTTTTTTTTTTTTTTTTTTTTTTT----|----|--- 16

-20000     -6000   DC    6     17 ----|----|----|----|----|----|----|----|--- 17
 -6000     -4000   DC    6     18 ----|----|----|----|----|----|---TTTTTTTTT- 18
 -4000     -2000   DC    6     19 ----|----|----|----|----T-TTTTTTT-|----|--T 19
 -2000     -1000   DC    6     20 ----|----|----|----|TTTT|T---|----|----|--- 20
 -1000     20000   DC    6     21 TTTTTTTTTTTTTTTTTTTT----|----|----|----|--- 21

-20000     -6000   DE    6     22 ----|----|----|----|----|----|----|----|--- 22
 -6000     -4000   DE    6     23 ----|----|----|----|----|----|----|----|--- 23
 -4000     -2000   DE    6     24 ----|----|----|----|----|----|--TTTTTTTTTT- 24
 -2000     -1000   DE    6     25 -TT-|T---|----|----|----|----|-T--|----|--T 25
 -1000     20000   DE    6     26 T--TT-TTTTTTTTTTTTTTTTTTTTTTTTT---|----|--- 26

     0         0   J     0     27                                             27
     0         0   J     0     28                                             28
     0         0   J     0     29                                             29
     0         0   J     0     30                                             30
     0         0   J     0     31                                             31
     0         0   J     0     32                                             32
     0         0   J     0     33                                             33
     0         0   J     0     34                                             34
     0         0   J     0     35                                             35
     0         0   J     0     36                                             36
     0         0   J     0     37                                             37
     0         0   J     0     38                                             38
     0         0   J     0     39                                             39
     0         0   J     0     40                                             40
     0         0   J     0     41                                             41
     0         0   J     0     42                                             42
     0         0   J     0     43                                             43
     0         0   J     0     44                                             44
     0         0   J     0     45                                             45
     0         0   J     0     46                                             46
     0         0   J     0     47                                             47
     0         0   J     0     48                                             48
     0         0   J     0     49                                             49
     0         0   J     0     50                                             50
     0         0   J     0     51                                             51
     0         0   J     0     52                                             52
     0         0   J     0     53                                             53
     0         0   J     0     54                                             54
     0         0   J     0     55                                             55
     0         0   J     0     56                                             56
     0         0   J     0     57                                             57
     0         0   J     0     58                                             58
     0         0   J     0     59                                             59
     0         0   J     0     60                                             60
                                  0000000001111111111222222222233333333334444
                                  1234567890123456789012345678901234567890123
```

TABLE D14 BTSM4.D1V

```
LOWER   UPPER  CO/T BQ    ROW
BOUND   BOUND       TYPE   #          Time ------>
                              0000000001111111111222222222233333333334444
                              1234567890123456789012345678901234567890123
-20000  -4000   D    1     1  TTTTTTTTTTTTTTTTTT-|----|----|----|----|---  1
 -4000  -2000   D    1     2  ----|----|----|---TT----|----|----|----|---  2
 -2000      0   D    1     3  ----|----|----|----|TTTT|----|----|----|---  3

 -2000   2000   DA   6     4  TTTTT---TTTTTTTT---TTTTTTTTTTTT---|----|---  4

 -2000   2000   DB   6     5  ----|----|----|----TTTTTTTTTTTTT--|----|--T  5

 -2000   2000   DC   6     6  ----|--T-|----|---TTTTTT|T---|----|----|---  6

 -2000   2000   DE   6     7  TTTTTTTTTTTTTTTTT--TTTTTTTTTTTTT--|----|--T  7
     0      0   J    0     8                                               8
     0      0   J    0     9                                               9
     0      0   J    0    10                                              10
     0      0   J    0    11                                              11
     0      0   J    0    12                                              12
     0      0   J    0    13                                              13
     0      0   J    0    14                                              14
     0      0   J    0    15                                              15
     0      0   J    0    16                                              16
     0      0   J    0    17                                              17
     0      0   J    0    18                                              18
     0      0   J    0    19                                              19
     0      0   J    0    20                                              20
     0      0   J    0    21                                              21
     0      0   J    0    22                                              22
     0      0   J    0    23                                              23
     0      0   J    0    24                                              24
     0      0   J    0    25                                              25
     0      0   J    0    26                                              26
     0      0   J    0    27                                              27
     0      0   J    0    28                                              28
     0      0   J    0    29                                              29
     0      0   J    0    30                                              30
     0      0   J    0    31                                              31
     0      0   J    0    32                                              32
     0      0   J    0    33                                              33
     0      0   J    0    34                                              34
     0      0   J    0    35                                              35
     0      0   J    0    36                                              36
     0      0   J    0    37                                              37
     0      0   J    0    38                                              38
     0      0   J    0    39                                              39
     0      0   J    0    40                                              40
     0      0   J    0    41                                              41
     0      0   J    0    42                                              42
     0      0   J    0    43                                              43
     0      0   J    0    44                                              44
     0      0   J    0    45                                              45
     0      0   J    0    46                                              46
     0      0   J    0    47                                              47
     0      0   J    0    48                                              48
     0      0   J    0    49                                              49
     0      0   J    0    50                                              50
     0      0   J    0    51                                              51
     0      0   J    0    52                                              52
     0      0   J    0    53                                              53
     0      0   J    0    54                                              54
     0      0   J    0    55                                              55
     0      0   J    0    56                                              56
     0      0   J    0    57                                              57
     0      0   J    0    58                                              58
     0      0   J    0    59                                              59
     0      0   J    0    60                                              60
                              0000000001111111111222222222233333333334444
                              1234567890123456789012345678901234567890123
```

TABLE D15 BTSM7.A1A

```
 LOWER    UPPER  CO/T  BQ    ROW
 BOUND    BOUND        TYPE   #          Time ------>
                                   00000000011111111112222222222333333333344
                                   12345678901234567890123456789012345678901
-20000    -9000   A     1      1   ----|----|----|----|----|----|----|----|-  1
 -9000    -8000   A     1      2   ----|----|----|----|----|----|----|----|-  2
 -8000    -7000   A     1      3   ----|----|----|----|----|----|----|----|-  3
 -7000    -6000   A     1      4   ----|----|----|----|----|----|----|----|-  4
 -6000    -5000   A     1      5   ----|----|----|----|----|----|----|----|-  5
 -5000    -4000   A     1      6   ----|----|----|----|----|----|----|----|-  6
 -4000    -3000   A     1      7   ----|----|----|----|----|----|----|----|-  7
 -3000    -2000   A     1      8   ----|----|----|----|----|----|----|----|-  8
 -2000    -1000   A     1      9   ----|----|----|----|----|----|----|----|-  9
 -1000        0   A     1     10   ----|----|----|----|----|----|----|----|- 10
     0     1000   A     1     11   ----|----|----|----|----|----|----|----|- 11
  1000    20000   A     1     12   TTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTT 12

    -1        5   A     2     13   TTTTTTTTTTTTTTTTTTTT---TT-TTTTTTTTTTTTTTT 13
     5       10   A     2     14   ----|----|----|----|TTT-|T---|----|----|- 14
    10       20   A     2     15   ----|----|----|----|----|----|----|----|- 15
    20       30   A     2     16   ----|----|----|----|----|----|----|----|- 16
    30       40   A     2     17   ----|----|----|----|----|----|----|----|- 17
    40       50   A     2     18   ----|----|----|----|----|----|----|----|- 18
    50       60   A     2     19   ----|----|----|----|----|----|----|----|- 19

    -1      100   A     3     20   ----|----|----|----|----|----|----|----|- 20
   100      200   A     3     21   ----|----|----|----|----|----|----|----|- 21
   200      300   A     3     22   ----|----|----|----|----|----|----|----|- 22
   300      400   A     3     23   ----|----|----|----|----|----|----|----|- 23
   400      500   A     3     24   ----|----|----|----|----|----|----|----|- 24
   500     1000   A     3     25   ----|----|----|----|----|----|----|----|- 25
  1000     1500   A     3     26   ----|----|----|----|----|----|----|----|- 26
  1500     2000   A     3     27   ----|----|----|----|T---|----|----|----|- 27
  2000     2500   A     3     28   TTTTTTTTTTTTTTTTTTTT-TTTTTTTTTTTTTTTTTTTT 28
  2500    20000   A     3     29   ----|----|----|----|----|----|----|----|- 29

-20000    -2500   A     4     30   ----|----|----|----T----|----|--TTTTTT-|- 30
 -2500    -2000   A     4     31   ----|----|----|----|----|----|----|---TTT 31
 -2000    -1500   A     4     32   ----|----|----|----|----|----|----|----|- 32
 -1500    -1000   A     4     33   ----|----|----|----|----|----|----|----|- 33
 -1000     -500   A     4     34   ----|----|----|----|----|----|----|----|- 34
  -500        0   A     4     35   ----|----|----|----|----|----|----|----|- 35
     0     1000   A     4     36   ----|----|----|----|----|----|----|----|- 36
  1000     1500   A     4     37   ----|----|----|----|----|----|----|----|- 37
  1500     2000   A     4     38   ----|----|----|----|----|----|----|----|- 38
  2000     2500   A     4     39   ----|----|----|----|----|----|----|----|- 39
  2500    20000   A     4     40   TTTTTTTTTTTTTTTTTTT|TTTTTTTTTTTT--|----|- 40

     0        0   J     0     41                                             41
     0        0   J     0     42                                             42
     0        0   J     0     43                                             43
     0        0   J     0     44                                             44
     0        0   J     0     45                                             45
     0        0   J     0     46                                             46
     0        0   J     0     47                                             47
     0        0   J     0     48                                             48
     0        0   J     0     49                                             49
     0        0   J     0     50                                             50
     0        0   J     0     51                                             51
     0        0   J     0     52                                             52
     0        0   J     0     53                                             53
     0        0   J     0     54                                             54
     0        0   J     0     55                                             55
     0        0   J     0     56                                             56
     0        0   J     0     57                                             57
     0        0   J     0     58                                             58
     0        0   J     0     59                                             59
     0        0   J     0     60                                             60
                                   00000000011111111112222222222333333333344
                                   12345678901234567890123456789012345678901
```

TABLE D16 BTSM7.A1B

```
LOWER    UPPER  CO/T BQ    ROW
BOUND    BOUND       TYPE   #           Time -------->
                                 00000000011111111112222222222333333333344
                                 12345678901234567890123456789012345678901
-20000   -9000   B    1     1    ----|----|----|----|----|----|----|----|-   1
 -9000   -8000   B    1     2    ----|----|----|----|----|----|----|----|-   2
 -8000   -7000   B    1     3    ----|----|----|----|----|----|----|----|-   3
 -7000   -6000   B    1     4    ----|----|----|----|----|----|----|----|-   4
 -6000   -5000   B    1     5    ----|----|----|----|----|----|----|----|-   5
 -5000   -4000   B    1     6    ----|----|----|--T-|----|----|----|----|-   6
 -4000   -3000   B    1     7    TTTTTTTTTTTTTT|----|----|----|----|----|-   7
 -3000   -2000   B    1     8    ----|----|----|----|----|----|----|----|-   8
 -2000   -1000   B    1     9    ----|----|----|----|----|----|----|----|-   9
 -1000       0   B    1    10    ----|----|----|----|----|----|----|----|-  10
     0    1000   B    1    11    ----|----|----|----|----|----|----|----|-  11
  1000   20000   B    1    12    ----|----|----TTT-TTTTTTTTTTTTTTTTTTTTTTT  12

    -1       5   B    2    13    TTTTTT-TTTTTTTTTTTTT--T-|TTTTTTTTTTTTTTTT  13
     5      10   B    2    14    ----|-T--|----|----|TT-T|----|----|----|-  14
    10      20   B    2    15    ----|----|----|----|----T----|----|----|-  15
    20      30   B    2    16    ----|----|----|----|----|----|----|----|-  16
    30      40   B    2    17    ----|----|----|----|----|----|----|----|-  17
    40      50   B    2    18    ----|----|----|----|----|----|----|----|-  18
    50      60   B    2    19    ----|----|----|----|----|----|----|----|-  19

    -1     100   B    3    20    ----|----|----|----|----|----|----|----|-  20
   100     200   B    3    21    ----|----|----|----|----|----|----|----|-  21
   200     300   B    3    22    ----|----|----|----|----|----|----|----|-  22
   300     400   B    3    23    ----|----|----|----|----|----|----|----|-  23
   400     500   B    3    24    ----|----|----|----|----|----|----|----|-  24
   500    1000   B    3    25    ----|----|----|----|----|----|----|----|-  25
  1000    1500   B    3    26    ----|----|----|----|-TTTTTTTTTTTTTTTTTTTT  26
  1500    2000   B    3    27    ----|-TTTTTTTTTTTTTTT---|----|----|----|-  27
  2000    2500   B    3    28    TTTTTT---|----|----|----|----|----|----|-  28
  2500   20000   B    3    29    ----|----|----|----|----|----|----|----|-  29

-20000   -2500   B    4    30    ----|----|----|----|----|----|----|----|-  30
 -2500   -2000   B    4    31    ----|----|----|----|----|----|----|----|-  31
 -2000   -1500   B    4    32    ----|----|----|----|----|----|----|----|-  32
 -1500   -1000   B    4    33    ----|----|----|----|----|----|----|----|-  33
 -1000    -500   B    4    34    ----|----|----|----|----|----|----|----|-  34
  -500       0   B    4    35    ----|----|----|----|----|----|----|----|-  35
     0    1000   B    4    36    ----|----|----|----|----|----|----|----|-  36
  1000    1500   B    4    37    ----|----|----|----|----|----|----|----|-  37
  1500    2000   B    4    38    ----|----|----|----|----|----|----|----|-  38
  2000    2500   B    4    39    ----|----|----|----|----|----|----|----|-  39
  2500   20000   B    4    40    TTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTT  40

     0       0   J    0    41                                               41
     0       0   J    0    42                                               42
     0       0   J    0    43                                               43
     0       0   J    0    44                                               44
     0       0   J    0    45                                               45
     0       0   J    0    46                                               46
     0       0   J    0    47                                               47
     0       0   J    0    48                                               48
     0       0   J    0    49                                               49
     0       0   J    0    50                                               50
     0       0   J    0    51                                               51
     0       0   J    0    52                                               52
     0       0   J    0    53                                               53
     0       0   J    0    54                                               54
     0       0   J    0    55                                               55
     0       0   J    0    56                                               56
     0       0   J    0    57                                               57
     0       0   J    0    58                                               58
     0       0   J    0    59                                               59
     0       0   J    0    60                                               60
                                 00000000011111111112222222222333333333344
                                 12345678901234567890123456789012345678901
```

TABLE D17 BTSM7.A1C

```
LOWER   UPPER  CO/T BQ    ROW
BOUND   BOUND       TYPE   #           Time ------>
                               00000000011111111112222222222333333333344
                               12345678901234567890123456789012345678901
-20000  -9000   C    1     1   ----|----|----|----|----|----|----|----|-  1
 -9000  -8000   C    1     2   TTTT|----|----|----|----|----|----|----|-  2
 -8000  -7000   C    1     3   ----TT---|----|----|----|----|----|----|-  3
 -7000  -6000   C    1     4   ----|-TTT|----|----|----|----|----|----|-  4
 -6000  -5000   C    1     5   ----|----TT---|----|----|----|----|----|-  5
 -5000  -4000   C    1     6   ----|----|-TT-|-TT-|----|----|----|----|-  6
 -4000  -3000   C    1     7   ----|----|---TTT--TT----|----|----|----|-  7
 -3000  -2000   C    1     8   ----|----|----|----|TTT-|----|----|----|-  8
 -2000  -1000   C    1     9   ----|----|----|----|---TTTTTTTTTTTT----|-  9
 -1000      0   C    1    10   ----|----|----|----|----|----|----|----|- 10
     0   1000   C    1    11   ----|----|----|----|----|----|----|----|- 11
  1000  20000   C    1    12   ----|----|----|----|----|----|----|TTTTTT 12

    -1      5   C    2    13   TTT-|TTT-|T---|--T-|--T-TTTTT|TTTT|TTTTTT 13
     5     10   C    2    14   ---TT---TT-TTTTTT-TTTT-T|----T----T----|- 14
    10     20   C    2    15   ----|----|----|----|----|----|----|----|- 15
    20     30   C    2    16   ----|----|----|----|----|----|----|----|- 16
    30     40   C    2    17   ----|----|----|----|----|----|----|----|- 17
    40     50   C    2    18   ----|----|----|----|----|----|----|----|- 18
    50     60   C    2    19   ----|----|----|----|----|----|----|----|- 19

    -1    100   C    3    20   ----|----|----|----|----|----|----|----|- 20
   100    200   C    3    21   ----|----|----|----|----|----|----|----|- 21
   200    300   C    3    22   ----|----|----|----|----|----|----|----|- 22
   300    400   C    3    23   ----|----|----|----|----|----|----|----|- 23
   400    500   C    3    24   TT--|----|----|----|----|----|----|-T-T|- 24
   500   1000   C    3    25   --TTTTT--|----|----|----|----|----TT-T-TT 25
  1000   1500   C    3    26   ----|--TTTT---|----|----|----|----|----|- 26
  1500   2000   C    3    27   ----|----|-TTTT----|-TTTTT---|--TT|----|- 27
  2000   2500   C    3    28   ----|----|----|T---T----|-TTTTTT--|----|- 28
  2500  20000   C    3    29   ----|----|----|-TTT|T---|----|----|----|- 29

-20000  -2500   C    4    30   ----|----|----|---T|----|----|----|----|- 30
 -2500  -2000   C    4    31   ----|----|---TTTTT-TT---|----|----|----|- 31
 -2000  -1500   C    4    32   ---T|-TT-|----|----|-TTTTTTT-|----|----|- 32
 -1500  -1000   C    4    33   TTT-|T--T|-TT-|----|----|---TT---T|----|T 33
 -1000   -500   C    4    34   ----T----TT---|----|----|----|TTT-T--TTT- 34
  -500      0   C    4    35   ----|----|----|----|----|----|----|TT--|- 35
     0   1000   C    4    36   ----|----|----|----|----|----|----|----|- 36
  1000   1500   C    4    37   ----|----|----|----|----|----|----|----|- 37
  1500   2000   C    4    38   ----|----|----|----|----|----|----|----|- 38
  2000   2500   C    4    39   ----|----|----|----|----|----|----|----|- 39
  2500  20000   C    4    40   ----|----|----|----|----|----|----|----|- 40

     0      0   J    0    41                                             41
     0      0   J    0    42                                             42
     0      0   J    0    43                                             43
     0      0   J    0    44                                             44
     0      0   J    0    45                                             45
     0      0   J    0    46                                             46
     0      0   J    0    47                                             47
     0      0   J    0    48                                             48
     0      0   J    0    49                                             49
     0      0   J    0    50                                             50
     0      0   J    0    51                                             51
     0      0   J    0    52                                             52
     0      0   J    0    53                                             53
     0      0   J    0    54                                             54
     0      0   J    0    55                                             55
     0      0   J    0    56                                             56
     0      0   J    0    57                                             57
     0      0   J    0    58                                             58
     0      0   J    0    59                                             59
     0      0   J    0    60                                             60
                               00000000011111111112222222222333333333344
                               12345678901234567890123456789012345678901
```

TABLE D18 BTSM7.A1D

```
 LOWER    UPPER  CO/T  BQ    ROW
 BOUND    BOUND       TYPE    #            Time ------->
                                   0000000001111111111222222222233333333334444
                                   1234567890123456789012345678901234567890123
-20000    -9000   D    1      1    TTTTTT---|----|----|----|----|----|----|---   1
 -9000    -8000   D    1      2    ----|-TTTT----|----|----|----|----|----|---   2
 -8000    -7000   D    1      3    ----|----|TTT-|----|----|----|----|----|---   3
 -7000    -6000   D    1      4    ----|----|---TT----|----|----|----|----|---   4
 -6000    -5000   D    1      5    ----|----|----|TTT-|----|----|----|----|---   5
 -5000    -4000   D    1      6    ----|----|----|----|----|----|----|----|---   6
 -4000    -3000   D    1      7    ----|----|----|---T|----|----|----|----|---   7
 -3000    -2000   D    1      8    ----|----|----|----T----|----|----|----|---   8
 -2000    -1000   D    1      9    ----|----|----|----|TT--|----|----|----|---   9
 -1000        0   D    1     10    ----|----|----|----|--TT|----|----|----|---  10
     0     1000   D    1     11    ----|----|----|----|----TTTTTT----|----|---  11
  1000    20000   D    1     12    ----|----|----|----|----|----|TTTTTTTTTTTTT  12

    -1        5   D    2     13    T---|----|TT--|----|-T--TTTTTT--T-TTTTTTT--  13
     5       10   D    2     14    ----|----|--T-TTTT-|T-TT|----|-T-T|----|---  14
    10       20   D    2     15    ----TTTTTT---T|---T|----|----|T---|----|-TT  15
    20       30   D    2     16    --TT|----|----|----T----|----|----|----|---  16
    30       40   D    2     17    -T--|----|----|----|----|----|----|----|---  17
    40       50   D    2     18    ----|----|----|----|----|----|----|----|---  18
    50       60   D    2     19    ----|----|----|----|----|----|----|----|---  19

    -1      100   D    3     20    T---|----|T--T|T---TTTTT|---TT----|----|---  20
   100      200   D    3     21    ---TTTT--|----T-TT-|----TTTT-|----|----|---  21
   200      300   D    3     22    ----|--T-T--T-|---T|----|----|----|----|---  22
   300      400   D    3     23    -T--|----|-T--|----|----|----|----|----|---  23
   400      500   D    3     24    ----|---T|----|----|----|----|T---|----|---  24
   500     1000   D    3     25    ----|----|----|----|----|----|-TTT|TTTTTTT-  25
  1000     1500   D    3     26    --T-|----|----|----|----|----|----T----|--T  26
  1500     2000   D    3     27    ----|----|----|----|----|----|----|----|---  27
  2000     2500   D    3     28    ----|----|----|----|----|----|----|----|---  28
  2500    20000   D    3     29    ----|----|----|----|----|----|----|----|---  29

-20000    -2500   D    4     30    TT--|----|----|----|----|----|----|----|---  30
 -2500    -2000   D    4     31    --T-|----|----|----|----|----|----|----|---  31
 -2000    -1500   D    4     32    ----|----|----|----|----|----|----|----|---  32
 -1500    -1000   D    4     33    ----T----|----|----|----|----|----|----|---  33
 -1000     -500   D    4     34    ---T|----|----|----|----|----|----|----|---  34
  -500        0   D    4     35    ----|----|----|----|----|----|----|----|---  35
     0     1000   D    4     36    ----|----|----|----|----|----|----|----|---  36
  1000     1500   D    4     37    ----|----|----|----|----|----|----|----|---  37
  1500     2000   D    4     38    ----|----|----|----|----|----|----|----|---  38
  2000     2500   D    4     39    ----|T---|----|----|----|----|----|----|---  39
  2500    20000   D    4     40    ----|-TTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTT  40

     0        0   J    0     41                                                 41
     0        0   J    0     42                                                 42
     0        0   J    0     43                                                 43
     0        0   J    0     44                                                 44
     0        0   J    0     45                                                 45
     0        0   J    0     46                                                 46
     0        0   J    0     47                                                 47
     0        0   J    0     48                                                 48
     0        0   J    0     49                                                 49
     0        0   J    0     50                                                 50
     0        0   J    0     51                                                 51
     0        0   J    0     52                                                 52
     0        0   J    0     53                                                 53
     0        0   J    0     54                                                 54
     0        0   J    0     55                                                 55
     0        0   J    0     56                                                 56
     0        0   J    0     57                                                 57
     0        0   J    0     58                                                 58
     0        0   J    0     59                                                 59
     0        0   J    0     60                                                 60
                                   0000000001111111111222222222233333333334444
                                   1234567890123456789012345678901234567890123
```

TABLE D19 BTSM7.TFA

```
 LOWER    UPPER  CO/T  BQ    ROW
 BOUND    BOUND        TYPE   #          Time ------>
                                  00000000011111111112222222222333333333344
                                  12345678901234567890123456789012345678901
-20000    -7000   A     1     1   ----|----|----|----|----|----|----|----|-   1
 -7000    -6000   A     1     2   ----|----|----|----|----|----|----|----|-   2
 -6000    -5000   A     1     3   ----|----|----|----|----|----|----|----|-   3
 -5000    -4000   A     1     4   ----|----|----|----|----|----|----|----|-   4
 -4000    -3000   A     1     5   ----|----|----|----|----|----|----|----|-   5
 -3000    -2000   A     1     6   ----|----|----|----|----|----|----|----|-   6
 -2000    -1000   A     1     7   ----|----|----|----|----|----|----|----|-   7
 -1000        0   A     1     8   ----|----|----|----|----|----|----|----|-   8
     0     1000   A     1     9   ----|----|----|----|----|----|----|----|-   9
  1000    20000   A     1    10   TTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTT  10

-20000    -7000   B     1    11   ----|----|----|----|----|----|----|----|-  11
 -7000    -6000   B     1    12   ----|----|----|----|----|----|----|----|-  12
 -6000    -5000   B     1    13   ----|----|----|----|----|----|----|----|-  13
 -5000    -4000   B     1    14   ----|----|----|--T-|----|----|----|----|-  14
 -4000    -3000   B     1    15   TTTTTTTTTTTTTT|----|----|----|----|----|-  15
 -3000    -2000   B     1    16   ----|----|----|----|----|----|----|----|-  16
 -2000    -1000   B     1    17   ----|----|----|----|----|----|----|----|-  17
 -1000        0   B     1    18   ----|----|----|----|----|----|----|----|-  18
     0     1000   B     1    19   ----|----|----|----|----|----|----|----|-  19
  1000    20000   B     1    20   ----|----|----TTT-TTTTTTTTTTTTTTTTTTTTTTT  20

-20000    -7000   C     1    21   TTTTTT---|----|----|----|----|----|----|-  21
 -7000    -6000   C     1    22   ----|-TTT|----|----|----|----|----|----|-  22
 -6000    -5000   C     1    23   ----|----TT---|----|----|----|----|----|-  23
 -5000    -4000   C     1    24   ----|----|-TT-|-TT-|----|----|----|----|-  24
 -4000    -3000   C     1    25   ----|----|---TTT--TT----|----|----|----|-  25
 -3000    -2000   C     1    26   ----|----|----|----|TTT-|----|----|----|-  26
 -2000    -1000   C     1    27   ----|----|----|----|---TTTTTTTTTTTT----|-  27
 -1000        0   C     1    28   ----|----|----|----|----|----|----|----|-  28
     0     1000   C     1    29   ----|----|----|----|----|----|----|----|-  29
  1000    20000   C     1    30   ----|----|----|----|----|----|----|TTTTTT  30

-20000    -7000   D     1    31   ----|----|----|----|----|----|----|----|-  31
 -7000    -6000   D     1    32   ----|----|----|----|----|----|----|----|-  32
 -6000    -5000   D     1    33   ----|----|----|----|----|----|----|----|-  33
 -5000    -4000   D     1    34   TTTT|----|----|----|----|----|----|----|-  34
 -4000    -3000   D     1    35   ----TT---|----|----|----|----|----|----|-  35
 -3000    -2000   D     1    36   ----|-TTT|----|----|----|----|----|----|-  36
 -2000    -1000   D     1    37   ----|----TT---|----|----|----|----|----|-  37
 -1000        0   D     1    38   ----|----|-TTTT----|----|----|----|----|-  38
     0     1000   D     1    39   ----|----|----|----|----|----|----|----|-  39
  1000    20000   D     1    40   ----|----|----|TTTTTTTTTTTTTTTTTTTTTTTTTT  40

     0     3000   J     7    41   ----|----|----|----|----|----|----|T-TTTTTTTTT  41
  3000     4000   J     7    42   ----|----|----|----|----TTTTTT-T--|----|-  42
  4000     6000   J     7    43   ----|----|----|TTTTTTTTT|----|----|----|-  43
  6000     8000   J     7    44   ----|----TTTTTT----|----|----|----|----|-  44
  8000    20000   J     7    45   -TTTTTTTT|----|----|----|----|----|----|-  45

-20000   -10000   J     8    46   ----|----|----|----|----|----|----|----|-  46
-10000    -8000   J     8    47   -TT-|----|----|----|----|----|----|----|-  47
 -8000    -6000   J     8    48   ---TT-T--|----|----|----|----|----|----|-  48
 -6000    -4000   J     8    49   ----|T-TTTTT--|----|----|----|----|----|-  49
 -4000    -2000   J     8    50   ----|----|--TTT----|----|----|----|----|-  50
 -2000    -1000   J     8    51   ----|----|----|TTT-|----|----|----|----|-  51
 -1000     -500   J     8    52   ----|----|----|----|----|----|----|----|-  52
  -500        0   J     8    53   T---|----|----|----|----|----|----|----|-  53
     0      500   J     8    54   ----|----|----|----|----|----|----|----|-  54
   500    20000   J     8    55   ----|----|----|---TTTTTTTTTTTTTTTTTTTTTTTT  55

-10000    -5000   J     9    56   ----|----|----|----|----|----|----|----|-  56
 -5000    -2000   J     9    57   ----|----|----|----|----|----|----|----|-  57
 -2000     2000   J     9    58   T---T--TT|----|----|--TTTTTTTTTTTTTTTTTTTT  58
  2000     5000   J     9    59   -TTT|TT--TTTTTTTTTTTTT--|----|----|----|-  59
  5000    10000   J     9    60   ----|----|----|----|----|----|----|----|-  60
                                  00000000011111111112222222222333333333344
                                  12345678901234567890123456789012345678901
```

TABLE D20 BTSM7.C1W

```
 LOWER    UPPER CO/T BQ    ROW
 BOUND    BOUND      TYPE   #            Time ------>
                                 00000000011111111112222222222333333333344
                                 12345678901234567890123456789012345678901
-20000    -6000   C   1     1   TTTTTTTTT|----|----|----|----|----|----|-   1
 -6000    -4000   C   1     2   ----|----TTTT-|-TT-|----|----|----|----|-   2
 -4000    -2000   C   1     3   ----|----|---TTT--TTTTT-|----|----|----|-   3
 -2000    -1000   C   1     4   ----|----|----|----|---TTTTTTTTTTTT----|-   4
 -1000        0   C   1     5   ----|----|----|----|----|----|----|----|-   5
     0    20000   C   1     6   ----|----|----|----|----|----|----|TTTTTT   6

-20000    -6000   CA  6     7   ----|----|----|----|----|----|----|----|-   7
 -6000    -4000   CA  6     8   ----|----|----|----|----|----|----|----|-   8
 -4000    -2000   CA  6     9   ----|----|----|----|----|----|----|----|-   9
 -2000    -1000   CA  6    10   ----|----|----|----|----|----|----|----|-  10
 -1000    20000   CA  6    11   TTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTT  11

-20000    -6000   CB  6    12   ----|----|----|----|----|----|----|----|-  12
 -6000    -4000   CB  6    13   ----|----|----|----|----|----|----|----|-  13
 -4000    -2000   CB  6    14   ----|----|----|----|----|----|----|----|-  14
 -2000    -1000   CB  6    15   ----|----|----|----|----|----|----|----|-  15
 -1000    20000   CB  6    16   TTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTT  16

-20000    -6000   CD  6    17   ----|----|----|----|----|----|----|----|-  17
 -6000    -4000   CD  6    18   ----|----|----|----|----|----|----|----|-  18
 -4000    -2000   CD  6    19   ----|----|----|----|----|----|----|----|-  19
 -2000    -1000   CD  6    20   ----|----|----|----|----|----|----|----|-  20
 -1000    20000   CD  6    21   TTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTT  21

-20000    -6000   CE  6    22   ----|----|----|----|----|----|----|----|-  22
 -6000    -4000   CE  6    23   ----|----|----|----|----|----|----|----|-  23
 -4000    -2000   CE  6    24   ----|----|----|----|----|----|----|----|-  24
 -2000    -1000   CE  6    25   ----|----|----|----|----|----|----|----|-  25
 -1000    20000   CE  6    26   TTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTT  26

     0        0   J   0    27                                              27
     0        0   J   0    28                                              28
     0        0   J   0    29                                              29
     0        0   J   0    30                                              30
     0        0   J   0    31                                              31
     0        0   J   0    32                                              32
     0        0   J   0    33                                              33
     0        0   J   0    34                                              34
     0        0   J   0    35                                              35
     0        0   J   0    36                                              36
     0        0   J   0    37                                              37
     0        0   J   0    38                                              38
     0        0   J   0    39                                              39
     0        0   J   0    40                                              40
     0        0   J   0    41                                              41
     0        0   J   0    42                                              42
     0        0   J   0    43                                              43
     0        0   J   0    44                                              44
     0        0   J   0    45                                              45
     0        0   J   0    46                                              46
     0        0   J   0    47                                              47
     0        0   J   0    48                                              48
     0        0   J   0    49                                              49
     0        0   J   0    50                                              50
     0        0   J   0    51                                              51
     0        0   J   0    52                                              52
     0        0   J   0    53                                              53
     0        0   J   0    54                                              54
     0        0   J   0    55                                              55
     0        0   J   0    56                                              56
     0        0   J   0    57                                              57
     0        0   J   0    58                                              58
     0        0   J   0    59                                              59
     0        0   J   0    60                                              60
                                 00000000011111111112222222222333333333344
                                 12345678901234567890123456789012345678901
```

TABLE D21 BTSM7.C1V

```
 LOWER    UPPER  CO/T  BQ    ROW
 BOUND    BOUND        TYPE   #         Time ------->
                                  00000000011111111112222222222333333333344
                                  12345678901234567890123456789012345678901
-20000    -4000   C     1     1   TTTTTTTTTTTTT-|-TT-|----|----|----|----|-   1
 -4000    -2000   C     1     2   ----|----|---TTT--TTTTT-|----|----|----|-   2
 -2000        0   C     1     3   ----|----|----|----|---TTTTTTTTTTTT----|-   3

 -2000     2000   CA    6     4   ----|----|----|----|----|----|----|----|-   4

 -2000     2000   CB    6     5   ----|----|----|----|----|----|----TTTTTTT   5

 -2000     2000   CD    6     6   ----|----|----|----|----|----|----TTTTTTT   6

 -2000     2000   CE    6     7   TTTTTTT--T-T--|----|----|----|----|----|-   7

     0        0   J     0     8                                               8
     0        0   J     0     9                                               9
     0        0   J     0    10                                              10
     0        0   J     0    11                                              11
     0        0   J     0    12                                              12
     0        0   J     0    13                                              13
     0        0   J     0    14                                              14
     0        0   J     0    15                                              15
     0        0   J     0    16                                              16
     0        0   J     0    17                                              17
     0        0   J     0    18                                              18
     0        0   J     0    19                                              19
     0        0   J     0    20                                              20
     0        0   J     0    21                                              21
     0        0   J     0    22                                              22
     0        0   J     0    23                                              23
     0        0   J     0    24                                              24
     0        0   J     0    25                                              25
     0        0   J     0    26                                              26
     0        0   J     0    27                                              27
     0        0   J     0    28                                              28
     0        0   J     0    29                                              29
     0        0   J     0    30                                              30
     0        0   J     0    31                                              31
     0        0   J     0    32                                              32
     0        0   J     0    33                                              33
     0        0   J     0    34                                              34
     0        0   J     0    35                                              35
     0        0   J     0    36                                              36
     0        0   J     0    37                                              37
     0        0   J     0    38                                              38
     0        0   J     0    39                                              39
     0        0   J     0    40                                              40
     0        0   J     0    41                                              41
     0        0   J     0    42                                              42
     0        0   J     0    43                                              43
     0        0   J     0    44                                              44
     0        0   J     0    45                                              45
     0        0   J     0    46                                              46
     0        0   J     0    47                                              47
     0        0   J     0    48                                              48
     0        0   J     0    49                                              49
     0        0   J     0    50                                              50
     0        0   J     0    51                                              51
     0        0   J     0    52                                              52
     0        0   J     0    53                                              53
     0        0   J     0    54                                              54
     0        0   J     0    55                                              55
     0        0   J     0    56                                              56
     0        0   J     0    57                                              57
     0        0   J     0    58                                              58
     0        0   J     0    59                                              59
     0        0   J     0    60                                              60
                                  00000000011111111112222222222333333333344
                                  12345678901234567890123456789012345678901
```